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Volume 12, Number 7, July 1971

Radiological Health Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

Reports

Evaluation of Television Contribution to the Annual Genetically Significant Radiation Dose of the Population

X-Radiation Ad Hoc Committee, Electronic Industries Association[1]

The X-Radiation Ad Hoc Committee of the Electronic Industries Association has used data from a U.S. Public Health Service survey of color television receivers in the Washington, D.C. area to estimate the annual genetically significant x-radiation dose to the U.S. population from television usage. Using these data and various assumptions, the annual genetically significant dose was estimated by the committee to be 0.5 mrem.

In a recent study, the X-Radiation Ad Hoc Committee, Electronic Industries Association, used U.S. Public Health Service (PHS) survey data to estimate the annual genetically significant x-radiation dose to the U.S. population due to television usage.

The primary purpose of this study was to determine, to the extent possible, whether the dose to the U.S. population due to television usage in early 1968 exceeded the objective established by the National Council on Radiation Protection and Measurements. The results of this study along with the study methods are reviewed in this paper.

Also included in this paper is a current appraisal of steps which have been or are being taken to further limit x radiation from television sets.

The objective of the National Committee on Radiation Protection and Measurements

In 1960 the National Committee[2] on Radiation Protection and Measurements (NCRP) published recommendations with regard to the maximum permissible x-radiation dose from television receivers. The position adopted by the NCRP was published in *Radiology* in July 1960 along with information on the objective of this organization (*1*).

In an interim statement approved on February 23, 1968, the NCRP reaffirmed its earlier standard. In this statement, the NCRP objective was restated as follows:

"The judgement of the NCRP is that the use of television receivers in the home should not contribute to the annual genetically significant dose to the population in excess of about 5% of the average dose from natural background radiation (about 120 mrem)."

Since two terms used in the NCRP statement may be unfamiliar, some comments are in order.

Annual genetically significant dose to the population

The "annual genetically significant dose to the population" is a measure of the genetic significance of the yearly dose received by the population's reproductive organs (gonads). To calculate this dose, one must consider the gonad dose and the future number of children expected by each member of the population (table 1).

Natural background radiation

Natural background radiation consists of a broad spectrum of ionizing radiation, both electromagnetic and particulate. Its distinguishing characteristics are that the entire population of the world is exposed and the exposure rate varies considerably from place to place with geological conditions, altitude, and latitude.

Sources of natural background radiation can be generally grouped into sources that are external to the body and sources that are internal to the body.

---

[1] Study team members are Morris Broyles, GE; Orville Neely, Motorola (now with MGA); Roger Slinkman, Sylvania; and Charles Thierfelder, RCA.

[2] Now council.

Table 1. Average number of expected children[a]

Age	Population (percent)	Sex (percent)	Average expected children
0–14 years:			
Male	15.8	32.1	3.29
Female	15.4	30.1	3.16
15-44 years:			
Male	19.4	30.4	1.94
Female	20.1	39.6	1.5
45 years and older:			
Male	14.0	28.4	.0942
Female	15.3	30.2	.0014

[a] Taken from 1960 U.S. Census Bureau data.

Sources that are external include cosmic rays and radioisotopes found in the crust and atmosphere of the earth. Cosmic rays produce a gonadal dose at sea level of the order of 30 millirem per year. The dose rate at a height of 3,000 meters is approximately three times that at sea level.

Radionuclides are found in greatest concentration in various types of rocks and secondarily, in soil, water, air, and food. Radionuclides external to the body contribute approximately 70 millirem per year to the gonad dose in most locations. This dose may be higher, up to 830 millirem per year in certain parts of India where radionuclide concentrations are high in the rock formations and soil.

Sources that are internal consist of radiation from isotopes in the cells of the body and those taken in food and water. The primary internal radiation contribution to the gonadal dose is from potassium-40, which is about 20 millirem per year.

The summation of these sources adds up to an average value of about 120 millirem per year and ranges up to a maximum of about 880 millirem per year.

The Washington, D.C. survey

In early 1968, the National Center for Radiological Health (NCRH) (now the Bureau of Radiological Health (BRH), with the active cooperation of the Electronic Industries Association, completed a limited survey of x-radiation emissions from color television receivers. The purpose of this survey was to obtain information on the x-ray emission of television receivers of all manufacturers included in a sample of color television receivers in use in the homes of PHS employees in the Washington, D.C. area. In all, 1,124 color television sets of a variety of brand names and models from 21 domestic and five foreign manufacturers were included in the survey.

A report of the survey was published on March 12, 1968, by the Technical Services Branch, NCRH (2). The results given in that report are applicable to the sample of color television receivers in the Washington Metropolitan Area and may not necessarily be applicable to color television receivers in the rest of the country.

In the Washington, D.C. survey, x-radiation measurements were made at the point, 5 cm from each television receiver surface where maximum emissions were detected. Therefore, the data recorded for each set included six maximum measurements, one for each of the six surfaces of the set. Additionally, data were recorded when the receiver was operated with the user controls set to three positions as follows:

Position A	User controls set to positions customarily used when viewing.
Position B	Same as Position A except brightness control was set to maximum brightness position.
Position C	Same as Position A except brightness control was set to minimum brightness position.

The Washington, D.C. survey report noted that x-radiation emissions were not detected from any surface of 856 of the 1,124 sets surveyed (table 2). Additionally, x-radiation emissions were not detected from some of the surfaces of the other 268 sets. Since it is possible that instrumentation limitations prevented the detection and measurement of very low levels of x-radiation emission

Table 2. Distribution of color television receivers by the x-radiation exposure rate

X-radiation exposure rate (mR/h)	Number of receivers in range
<0.040	856
.040–<0.075	52
.075–< .125	38
.125–< .25	68
.25 –< .50	44
.50 –< 1.00	26
1.00 –< 2.00	23
2.00 –< 3.75	5
3.75 –< 7.50	5
7.50 –<12.50	5
≥12.50	2
Total sets	1,124

from some of these surfaces, the assumption was made for this report that there were emissions of 0.02 mR/h from all surfaces shown in the data as having emission of "less than 0.04 mR/h" (believed to be a very conservative assumption).

The Stoms' instruments used in the survey were designed and constructed by the NCRH expressly for the purpose of performing in-home measurements of x-radiation emissions from color television receivers. The radiation sensitive element of this instrument was an array of six Victoreen-type 1B85 Geiger-Mueller tubes.

For the purpose of the Washington survey, the survey instruments were calibrated with an x-radiation beam from a 6EF4 shunt regulator tube operated with 25 kilovolts between cathode and anode.

Using this calibration, 4,000 counts per minute were equated to 0.5 mR/h. As further experience was gained, it was found that an instrument utilizing a 1B85 Geiger-Mueller tube could not be used to reliably measure the varied x-radiation emission from television receivers unless each emission is analyzed for energy distribution and the instrument is calibrated for all radiation energies to be measured. Table 3 shows a calibration currently being used for a Stoms' instrument.

Table 3. Bureau of Radiological Health calibration for Storms survey instrument[a] (Instrument #41)

Voltage (keV)	K radiating element	0.5 mR/h equals	1.0 mR/h equals
22.2	Silver	8,000 counts/min.	16,000 counts/min.
25.3	Tin	9,500 counts/min.	20,000 counts/min.
26.4	Antimony	10,000 counts/min.	
32.2	Barium	13,000 counts/min.	
33.4	Lanthanum	13,000 counts/min.	
37.4	Neodymium	13,000 counts/min.	
40.1	Samarium	12,000 counts/min.	
43.0	Gadolinium	12,000 counts/min.	
46.0	Dysprosium	10,000 counts/min.	
49.1	Erbium	9,000 counts/min.	

[a] All conversion factors are ±20 percent or greater.

This new calibration would indicate that when measuring emissions from color picture tube faceplates, 8,000 to 13,000 counts per minute rather than 4,000 counts per minute would equate to 0.5 mR/h. In the course of this study, no attempt was made to use this new calibration even though to do so would lower many of the emission levels reported in the Washington, D.C. survey.

Limited information on viewing habits was obtained through discussions with household members while the survey measurements were being made. These data are recorded in table 4.

The x radiation from any single set surveyed will vary with time depending upon variations in line voltage, signal conditions, user control adjustments, service control adjustments, and the failure and repair of sets. Even though this variability of any single set is recognized, it is expected that the average emission from a large number of sets, such as those surveyed in Washington, D.C., will remain reasonably constant. Therefore, this variability will not prevent the use of these data for estimating the annual genetically significant dose to the population.

Calculation methods

The following methods are for calculation of radiation from point sources, picture tube face plate and annual genetically significant dose. In this calculation, exposure to the younger individuals is weighed most heavily (table 1).

The annual skin dose to members of families who owned the color television sets surveyed by the Public Health Service in Washington, D.C. may be calculated using the following formula:

1. For radiation from point sources:

$$\text{Skin exposure} = \frac{1}{N} \sum_{i=1}^{N} \left[X_i \frac{H}{8} \left(\frac{I}{D+I} \right)^2 \right] = \frac{H}{8N} \left(\frac{I}{D+I} \right)^2 \sum_{i=1}^{N} X_i \qquad \ldots(1)$$

Where: X_i = Radiation in "i^{th}" television set (thousand counts per minute) measured 2 inches from surface,

I = Point source to meter distance = point source to cabinet surface in inches plus 2 inches,

D = Distance from meter to viewer = cabinet surface to viewer in inches minus 2 inches,

N = Number of receivers in survey,

1/8 = Converts thousand counts per minute to mR/h,

H = Average number of color viewing hours per year per person, and

Skin exposure = Annual accumulation in mR.

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Table 4. Household members by age, by normal viewing distance and hours per week viewing time

Viewing time by age groups (hours per week)	Number of persons by viewing distance						
	Under 4 feet	4–7 feet	8–11 feet	12–15 feet	16 feet or greater	Not indicated	Total
All ages: (years)	84	659	969	484	71	44	2,311
≤15	49	290	442	225	39	16	1,061
16–30	24	239	376	179	19	8	845
≥31	11	127	148	78	13	3	380
Not indicated	0	3	3	2	0	17	25
Under 15 years old:	48	280	150	39	6	24	547
≤15	22	100	53	10	5	8	198
16–30	18	104	64	25	1	7	219
≥31	8	74	33	4	0	1	120
Not indicated	0	2	0	0	0	8	10
15–44 years old:	23	232	497	255	30	12	1,049
≤15	16	123	242	134	14	7	536
16–30	5	78	189	79	8	1	360
≥31	2	30	65	42	8	2	149
Not indicated	0	1	1	0	0	2	4
45 years old and over:	13	147	322	190	35	8	715
≤15	11	67	147	81	20	1	327
16–30	1	57	123	75	10	0	266
≥31	1	23	50	32	5	0	111
Not indicated	0	0	2	2	0	7	11

2. For radiation through faceplate of picture tube:

$$\text{Skin exposure} = \frac{1}{N}\sum_{i=1}^{N}\left[X_i \frac{H}{8} K\right]$$

$$= \frac{HK}{8N}\sum_{i=1}^{N} X_i \qquad \ldots(2)$$

Where: K = Correction factor for distance = radiation at distance D divided by radiation measured 2 inches from safety panel.

3. For calculation of male and female gonadal dose:

The annual per capita gonad dose can be calculated from the average skin exposure by using correction factors K_M and K_F:

Where: K_M = Depth dose at male gonads/skin exposure,

K_F = Depth dose at female gonads/skin exposure.

4. For calculation of the genetically significant dose:

The equation for genetically significant dose from UNSCEAR (*3*) was used for calculation of the genetically significant dose.

$$D = \frac{\sum_J \sum_K \left(N^F_{JK} W^F_{JK} d^F_{JK} + N^M_{JK} W^M_{JK} d^M_{JK}\right)}{\sum_K \left(N^F_K W^F_K + N^M_K W^M_K\right)} \qquad \ldots(3)$$

Where: D = Annual genetically significant dose,

N_{JK} = Annual number of individuals of age-class K, subjected to class J exposure,

N_K = Total number of individuals of age-in-class K,

[3]W_{JK} = Future average number of children expected by an exposed individual of age-in-class K subsequent to a class J exposure,

W_K = Future number of children expected by an average individual of age-in-class K,

d_{JK} = Gonad dose per class J exposure of an individual of age-in-class K, and

F and M = Denote "female" and "male" respectively.

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---

[3] Since the radiation levels from television are quite low, the number of expected children will be the same for individuals after irradiation as it was before. Therefore, for the purposes of these calculations W_{JK} will be assumed to be the same as W_K.

Calculations

The annual genetically significant dose to the U.S. population was estimated in this report to be 1.9 mrem based on the assumptions that (1) the entire population (in all 59.8 million U.S. households) was exposed to color television sets like those measured in Washington, D.C. in early 1968 and (2) viewing habits of the U.S. population matched the viewing habits recorded in Washington, D.C. The assumptions and computer calculations used in estimating this dose are outlined below.

A. The annual genetically significant dose to viewers was estimated to be 1.8 mrem using the following data and assumptions and calculation methods detailed above.

1. Emissions are those recorded in the Washington, D.C. survey from the fronts of color television receivers when user controls were set to positions customarily used when viewing receivers.

2. Data on viewing distance and viewing time were taken from table 4 and sex distribution of the U.S. population. The assumptions in tables 5 and 6 were used to simplify the calculations.

Table 5. Viewing distance assumptions

Viewing distance from table 4 (feet)	Viewing distance used in calculations (feet)
<4	3.0
4 to 7	5.5
8 to 11	9.5
12 to 15	13.5
≥16	16.0

Table 6. Viewing hours assumptions

Viewing hours per week from table 4	Viewing hours per week used in calculations
<15	10 (520 hours per year)
16–30	23 (1,196 hours per year)
≥31	40 (2,080 hours per year)

3. The following correction factors were used to calculate x-radiation levels at the various viewing distances. Since the x-radiation measurements were made 2 inches from the surface of the sets, it is necessary to calculate the actual viewer exposure based on distance from set. (The correction factors were supplied by Mr. Shih-Ping Wang, Zenith Radio Corporation.)

Viewing distance (feet)	Correction factor (percent)
3.0	22.0
5.5	8.9
9.5	3.1
13.5	1.6
16.0	1.1

4. The central axis depth dose factors used to calculate depth dose to the gonads from air dose were 72 percent for males and 11 percent for females. (These factors, based on measurements by Braestrup (4), were supplied by Robert D. Moseley, Jr., M.D., Professor and Chairman, Department of Radiology, the University of Chicago.)

B. The annual genetically significant dose to non-viewers was estimated to be about 5 percent of the dose to viewers.

The Washington, D.C. survey report did not provide information on exposure time or exposure distance for non-viewers. In order to estimate the dose to non-viewers, calculations were made using the following data and assumptions:

1. Emissions were those recorded in the Washington, D.C. survey from the back, top, bottom, and sides of color television sets when user controls were set to positions customarily used when viewing receivers.

2. Persons located at back, top, bottom or sides of operating sets were considered to be non-viewers. Average exposure times were assumed to be 100 to 200 hours per year.

3. Emissions from back, top, bottom and sides of receivers originate at point sources. The assumed distances from the point source to the surface of the receiver were as follows:

Back	4 to 8 inches
Top	6 to 12 inches
Bottom	6 to 12 inches
Left side	4 to 8 inches
Right side	4 to 8 inches

Typically, the distance from the receiver surface to receiver components which may be x-radiation sources is bracketed by the distances listed above.

4. The distance from the set surface to non-viewers was assumed to be 3 feet to 7 feet. These distances were chosen to bracket the most likely average distance between the set and non-viewers who are in the vicinity of operating receivers.

Using the data, assumptions, and calculation methods detailed above, the skin exposure of non-viewers of the color television sets surveyed in Washington, D.C. was calculated. It was found that the skin exposure of non-viewers was approximately 5 percent of the skin exposure to viewers. Using the same depth dose factors used for calculating dose to viewers, the annual genetically significant dose to non-viewers was estimated to be 0.1 mrem (5 percent of the dose to viewers).

C. By summing the above doses to viewers and non-viewers, the annual genetically significant dose to the U.S. population was estimated to be 1.9 mrem assuming the entire U.S. population was exposed to color television sets like those surveyed in Washington, D.C., and assuming the viewing habits of the U.S. population matched the viewing habits recorded in Washington, D.C.

The annual genetically significant dose to the U.S. population from radiation emanating from color and monochrome television in use in early 1968 was estimated to be 0.5 mrem based on the following assumptions and calculations.

At the time of the Washington, D.C. survey, there were in the United States 14.1 million color television households, 42.3 million monochrome television households, and 3.4 million non-television households. There were 5.7 percent of U.S. households without television, 23.7 percent with color television and 70.6 percent with monochrome television.

There appears to be general agreement that little, if any, x radiation is emitted from the monochrome television sets in use. Furthermore, the depth dose factor' for monochrome sets operating at lower tube voltages, is lower. In order to make a conservative estimate, the assumption was made that the annual genetically significant dose to residents in monochrome television households was 0.1 mrem or about 5 percent of the estimated dose of residents of color television households.

From the above data and assumptions, the annual genetically significant dose to the U.S. population is estimated to be 0.5 mrem. This dose is less than ½ of 1 percent of the average dose from natural background radiation (about 120 mrem) and is well within the maximum permissible dose from television receivers of 6 mrem recommended by the National Council on Radiation Protection and Measurements.

Current appraisal

There is evidence to indicate a downward trend in x-radiation emissions for color television receivers sold after 1964. The percentage of color television receivers included in the Washington, D.C. survey emitting 0.5 mR/h or more by years of purchase is shown in figure 1, and those sets emitting 0.25 mR/h or more by year of purchase are shown in figure 2.

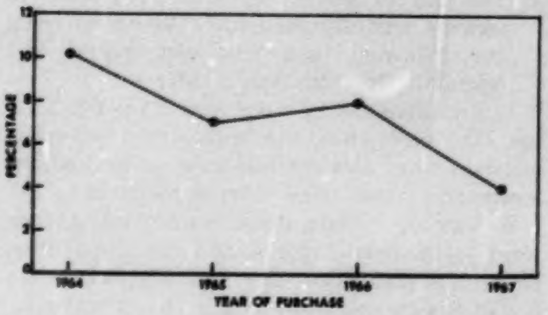

Figure 1. Percentage of color television receivers included in the Washington, D.C. survey emitting 0.5 mR/h or more, by year of purchase

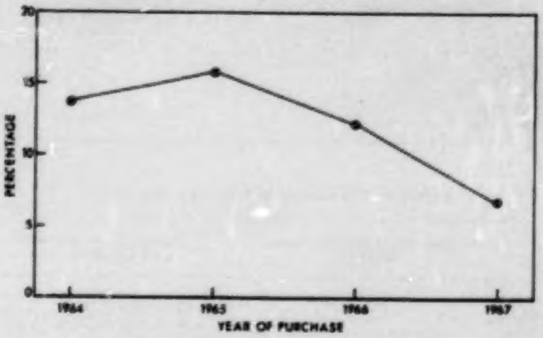

Figure 2. Percentage of color television receivers included in the Washington, D.C. survey emitting 0.25 mR/h or more, by year of purchase

"Electronic Industries Association's Ad Hoc Committee on X radiation from Television Receivers" has conducted five industry audits to monitor the trend in x-radiation emissions from color television receivers manufactured between 1964 and March 15, 1970. The number of color

Table 7. Color television receivers by x-radiation exposure rate and manufacturing date[a]

Reporting period	Number of receivers				
	X-radiation exposure rate (mR/h)				
	Background	>Background to <0.3	0.3–0.5	Over 0.5	Total
1964–June 1967	246	278	31	18	573
July 1967–February 1968	11,696	7,508	17	4	19,225
March 1968–April 1969	77,975	61,391	41	21	139,428
May 1969–September 1969	31,351	13,907	33	28	45,319
October 1969–March 1970	24,990	23,407	6	—	48,403

[a] The percent of color television receivers monitored emitting 0.3 mR/h or more has decreased from 8.5 percent in the 1964 to June 1967 manufacturing reporting period to 0.012 percent with no reading exceeding 0.5 mR/h in the October 1969 to March 15, 1970 manufacturing period.

television receivers by x-radiation exposure rate and manufacturing date are tabulated in table 7.

This downward trend in x-radiation exposure rate for television receivers is a consequence of the combined effort of the BRH, the television industry, and the Underwriters' Laboratories. In 1968 and 1969, the industry had developed improved electronic components, circuit design, radiation measuring and monitoring instrumentation, and manufacturing and control procedures to assure compliance with the NCRP recommendation and to meet the more stringent Federal standards which became effective on June 1, 1970.

Progress in this area is continuing. A major undertaking, which is presently underway, involves the design and production of a new family of picture tubes for use in color television. These tubes will incorporate glassware especially formulated to control x-radiation emission when picture tubes are subjected to extreme abnormal operating conditions. These new picture tubes, along with other advances will make possible industry compliance with the new, even more stringent Federal standards which became effective on June 1, 1971.

Conclusions

The judgment of the National Council on Radiation Protection and Measurements is that "the use of television receivers in the home should not contribute to the annual genetically significant dose of the population in excess of about 5 percent of the average dose from natural background radiation (about 120 millirem in a year)." This study of the Washington, D.C. survey data gives evidence that the annual genetically significant dose due to television usage in early 1968 was about 0.5 millirem, or less than ½ of 1 percent of the average dose from natural background radiation.

The Washington, D.C. survey data also provide evidence to indicate a downward trend in x-radiation emissions for color television receivers sold after 1964. A similar trend is shown in data collected by the Electronic Industries Association for color sets manufactured in the period, 1964 through March 15, 1970.

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Dr. Robert D. Moseley, Jr., Professor and Chairman, Department of Radiology, University of Chicago, Chicago, Ill.

Dr. Harold O. Wyckoff, Chairman of the International Commission on Radiological Units and Measurements.

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, March 1971

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of

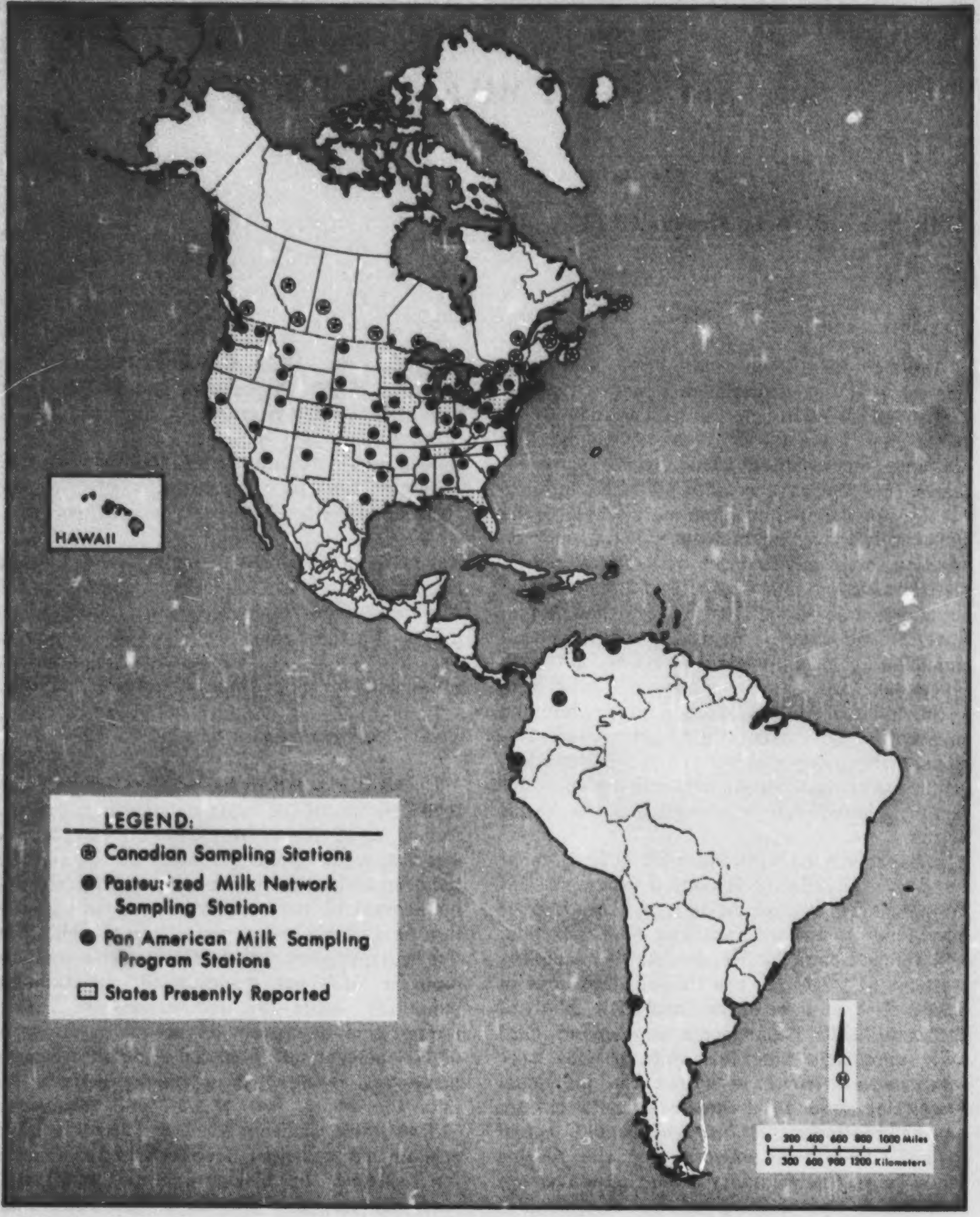
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
● Pan American Milk Sampling Program Stations
▨ States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2-standard deviations (2 σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, National, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during May–July 1970, with 28 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 (*5*). Of the 18 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 13 participated in the experiment.

The accuracy results of this experiment are shown in table 1. In general, considerable improvement is needed, especially in the accuracy measurements. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration		Number of laboratories in each category			
		Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Strontium-89:	High (258 pCi/liter)	7 (44%)	1 (6%)	8 (50%)	16
	Low (15 pCi/liter)	11 (69%)	3 (19%)	2 (12%)	16
Strontium-90:	Intermediate (79.4 pCi/liter)	13 (57%)	4 (17%)	6 (26%)	23
	Low (32.0 pCi/liter)	5 (25%)	4 (20%)	11 (55%)	20
Iodine-131:	High (507 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
	Low (49 pCi/liter)	16 (64%)	3 (12%)	6 (24%)	25
Cesium-137:	High (259 pCi/liter)	20 (74%)	3 (11%)	4 (15%)	27
	Low (53 pCi/liter)	17 (65%)	5 (19%)	4 (15%)	26
Barium-140:	High (302 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
	Low (33 pCi/liter)	23 (92%)	0	2 (8%)	25

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

A previous article (6) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data presentation, table 2, also reflects whether raw or pasteurized milk was collected. An analysis (7) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (7). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses (3). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (3). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance

Table 2. Concentrations of radionuclides in milk for March 1971 and 12-month period, April 1970 through March 1971

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	NA	8	0	0	11	9
Alaska:	Palmer[c]	P	3	5	0	0	15	11
Ariz:	Phoenix[c]	P	NA	1	0	0	0	0
Ark:	Little Rock[c]	P	10	13	0	0	0	11
Calif:	Sacramento[c]	P	NA	2	0	0	0	0
	San Francisco[c]	P	NA	2	0	0	0	0
	Del Norte	P	7	16	0	0	0	11
	Fresno	P	0	2	0	0	0	0
	Humboldt	P	8	5	0	0	0	4
	Los Angeles	P	2	[illegible]	0	0	0	0
	Mendocino	P	2	3	0	0	0	1
	Sacramento	P	8	3	0	0	0	1
	San Diego	P	0	2	0	0	0	0
	Santa Clara	P	0	2	0	0	0	1
	Shasta	P	3	3	0	0	0	2
	Sonoma	P	2	3	0	0	0	1
Colo:	Denver[c]	P	NA	5	0	0	0	1
	West	R	(d)		NS	•1	NS	•1
	Northeast	R	(d)		NS	•0	NS	•0
	East	R	(d)		NS	•0	NS	•0
	Southeast	R	(d)		•0	•0	•0	•0
	South Central	R	(d)		•0	•0	•0	•0
	Southwest	R	(d)		•0	•0	•0	•3
	Northwest	R	(d)		NS	•0	NS	•0
Conn:	Hartford[c]	P	NA	8	0	0	16	12
	Central	P	7	7	0	0	12	15
Del:	Wilmington[c]	P	NA	9	0	0	0	8
D.C:	Washington[c]	P	NA	7	0	0	16	8
Fla:	Tampa[c]	P	6	5	0	0	47	51
	West	R	6	9	0	0	17	21
	North	R	4	10	0	0	24	27
	Northeast	R	8	6	0	0	29	36
	Central	R	8	6	0	0	28	49
	Tampa Bay area	P	8	6	0	0	48	50
	Southeast	P	8	7	0	1	74	80
Ga:	Atlanta[c]	P	NA	12	0	0	12	14
Hawaii:	Honolulu[c]	P	5	2	0	0	0	0
Idaho:	Idaho Falls[c]	P	5	5	0	0	13	8
Ill:	Chicago[c]	P	6	7	0	0	16	11
Ind:	Indianapolis[c]	P	NA	8	0	0	0	7
	Northeast	P	10	10	0	0	15	13
	Southeast	P	9	11	0	0	10	10
	Central	P	8	9	0	5	10	10
	Southwest	P	10	12	0	0	0	9
	Northwest	P	11	11	0	0	10	12
Iowa:	Des Moines[c]	P	NA	6	0	0	0	3
	Iowa City	P	7	8	0 (2)	0	18 (2)	13
	Des Moines	P	6	8	0 (5)	0	12	11
	Spencer	P	5	5	0	0	17	8
	Fredericksburg	P	NS	NS	NS	NS	NS	NS
Kans:	Wichita[c]	P	NA	8	0	0	0	3
	Coffeyville	P	8	9	0	2	11	4
	Dodge City	P	6	7	0	2	12	2
	Falls City	R	7	12	0	3	11	8
	Hays	P	8	12	10	2	10	8
	Kansas City	P	8	8	14	3	24	11
	Topeka	P	5	10	0	2	12	8
	Wichita	P	7	11	0	0	12	4
Ky:	Louisville[c]	P	NA	10	0	0	0	3
La:	New Orleans[c]	P	13	14	0	0	17	10
Maine:	Portland[c]	P	NA	10	0	0	19	21
Md:	Baltimore[c]	P	NA	8	0	0	11	7
Mass:	Boston[c]	P	8	10	0	0	19	22
Mich:	Detroit[c]	P	NA	8	0	0	18	10
	Grand Rapids[c]	P	NA	10	0	0	11	14
	Bay City	P	NA	7	•0	•0	20	13
	Charlevoix	P	NA	12	•0 (4)	1	17 (4)	15
	Detroit	P	NA	8	•0	•0	10	8
	Grand Rapids	P	NA	9	•0	•0	14	8
	Lansing	P	NA	9	•0 (2)	•0	15 (2)	14
	Marquette	P	11	13	•0 (3)	•0	20 (3)	22
	Monroe	P	6	6	•0 (3)	•0	9 (3)	3
	South Haven	P	8	8	•0 (4)	•0	4 (4)	5
Minn:	Minneapolis[c]	P	NA	10	0	0	13	12
	Bemidji	P	11	8	0	0	25	21
	Mankato	P	6	5	0	0	0	16
	Rochester	P	8	7	0	0	0	12
	Duluth	P	18	13	0	0	26	26
	Worthington	P	0	4	0	0	0	0
	Minneapolis	P	11	11	0	0	17	17

See footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for March 1971 and 12-month period, April 1970 through March 1971--Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES: Continued								
	Fergus Falls	P	7	8	0	0	12	12
	Little Falls	P	17	12	0	0	20	24
Miss:	Jackson[c]	P	NA	12	0	0	0	9
Mo:	Kansas City[c]	P	NA	9	0	0	0	3
	St. Louis[c]	P	NA	9	0	0	0	4
Mont:	Helena[c]	P	NA	8	0	0	15	9
Nebr:	Omaha[c]	P	NA	4	0	0	0	1
Nev:	Las Vegas[c]	P	NA	3	0	0	0	0
N.H:	Manchester[c]	P	NA	9	0	0	18	21
N.J:	Trenton[c]	P	NA	7	0	0	15	11
N. Mex:	Albuquerque[c]	P	NA	3	0	0	0	0
N.Y:	Buffalo[c]	P	6	7	0	0	13	11
	New York City[c]	P	NA	10	0	0	16	16
	Syracuse[c]	P	NA	7	0	0	16	10
	Albany	P	9	8	0	0	<0	0
	Massena	P	8	9	0 (2)	0	22 (2)	25
	Newburg	P	5	8	0 (5)	0	<0 (5)	0
	New York City	P	9	10	0	0	<0	0
	Syracuse	P	6	4	0	0	0	0
N.C:	Charlotte[c]	P	NA	11	0	0	11	11
N.Dak:	Minot[c]	P	NA	9	0	0	11	11
Ohio:	Cincinnati[c]	P	NA	8	0	0	0	3
	Cleveland[c]	P	NA	9	0	0	0	12
Okla:	Oklahoma City[c]	P	NA	7	0	0	16	7
Oreg:	Portland[c]	P	0	5	0	0	0	4
	Baker	P	4	<0	<0	<0	22	9
	Coos Bay	P	4	3	<0	<0	<0	12
	Eugene	P	4	3	<0	<0	<0	1
	Medford	P	3	3	<0	<0	17	0
	Portland composite	P	10	6	<0	<0	<0	8
	Portland local	P	8	6	<0	<0	30	7
	Redmond	P	8	2	<0	<0	<0	<0
	Tillamook	P	NA	7	<0	<0	<0	17
Pa:	Philadelphia[c]	P	NA	9	0	0	11	7
	Pittsburgh[c]	P	NA	11	0	0	18	15
	Dauphin	P	7	7	0	2	21	12
	Erie	P	9	10	0	0	22	22
	Philadelphia	P	12	9	0	0	0	15
	Pittsburgh	P	13	12	0	1	21	20
R.I:	Providence[c]	P	NA	9	0	0	19	19
S.C:	Charleston[c]	P	9	10	0	1	14	17
S.Dak:	Rapid City[c]	P	7	7	0 (3)	0	6 (3)	8
Tenn:	Chattanooga[c]	P	NA	10	0	0	11	9
	Memphis[c]	P	NA	9	0	0	0	7
	Chattanooga	P	9	9	0	0	18	15
	Clinton	P	9	11	0 (3)	0	20	16
	Fayetteville	P	NS	12	NS	0	NS	14
	Knoxville	P	9	7	0 (3)	0	21	13
	Nashville	P	6	9	0	0	23	11
Tex:	Austin[c]	P	NA	8	0	0	0	2
	Dallas[c]	P	NA	7	0	0	14	6
	Amarillo	R	3	4	NS	NA	0	6
	Corpus Christi	R	NS	3	NS	0	0	0
	El Paso	R	NS	3	NS	NA	0	2
	Fort Worth	R	NS	6	NS	NA	0	0
	Harlingen	R	3	2	NS	NA	0	0
	Houston	R	NS	6	NS	NA	0	14
	Lubbock	R	NS	3	NS	NA	0	0
	Midland	R	NS	3	NS	NA	0	0
	San Antonio	R	3	3	NS	NA	0	0
	Texarkana	R	NS	8	NS	NA	0	0
	Tyler	R	10	13	NS	NA	10	13
	Uvalde	R	NS	2	NS	NA	0	0
	Wichita Falls	R	NS	8	NS	NA	0	0
Utah:	Salt Lake City[c]	P	0	4	0	0	0	11
Vt:	Burlington[c]	P	NA	8	0	0	16	15
Va:	Norfolk[c]	P	NA	9	0	0	0	8
Wash:	Seattle[c]	P	NA	5	0	0	0	3
	Spokane[c]	P	NA	6	0	0	0	1
	Benton County	R	3	1	0	0	0	2
	Franklin County	R	NS	3	NS	0	NS	3
	Sandpoint, Idaho	R	13	11	0	0	18	22
	Skagit County	R	6	6	0	0	11	11
W.Va:	Charleston[c]	P	NA	8	0	0	12	6
Wis:	Milwaukee[c]	P	NA	6	0	0	20	13
Wyo:	Laramie[c]	P	NA	5	0	0	0	1
CANADA:								
Alberta:	Calgary	P	7	7	(d)		16	17
	Edmonton	P	7	7	(d)		24	21

See footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for March 1971 and 12-month period, April 1970 through March 1971—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA: Continued								
British Columbia:	Vancouver	P	7	9	(d)		17	24
Manitoba:	Winnipeg	P	7	7	(d)		21	24
New Brunswick:	Fredericton	P	11	12	(d)		28	24
Newfoundland:	St. John's	P	12	17	(d)		18	33
Nova Scotia:	Halifax	P	9	11	(d)		24	21
Ontario:	Ottawa	P	13	14	(d)		30	24
	Sault Ste. Marie	P	11	12	(d)		26	25
	Thunder Bay	P	6	6	(d)		16	15
	Toronto	P	5	4	(d)		17	11
	Windsor	P	5	5	(d)		14	11
Quebec:	Montreal	P	7	7	(d)		21	19
	Quebec	P	9	9	(d)		30	29
Saskatchewan:	Regina	P	7	7	(d)		17	14
	Saskatoon	P	7	9	(d)		17	17
CENTRAL AND SOUTH AMERICA:								
Colombia:	Bogota	P	2	1	0	0	0	0
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Mandeville	P	NS	5	NS	0	NS	71
Venezuela:	Caracas	P	0	1	0	0	0	0
Canal Zone:	Cristobal[c]	P	NA	1	0	0	0	9
Puerto Rico:	San Juan[c]	P	NA	4	0	0	12	8
PMN network average[f]			6	7	0	0	8	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado–25 pCi/liter
Michigan–14 pCi/liter
Oregon–15 pCi/liter

Cesium-137: Colorado–25 pCi/liter
New York–20 pCi/liter
Oregon–15 pCi/liter

Strontium-90: New York–3 pCi/liter

[f] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote c.
NA, no analysis.
NS, no sample collected.

provided by the Federal Radiation Council for specific environment conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion

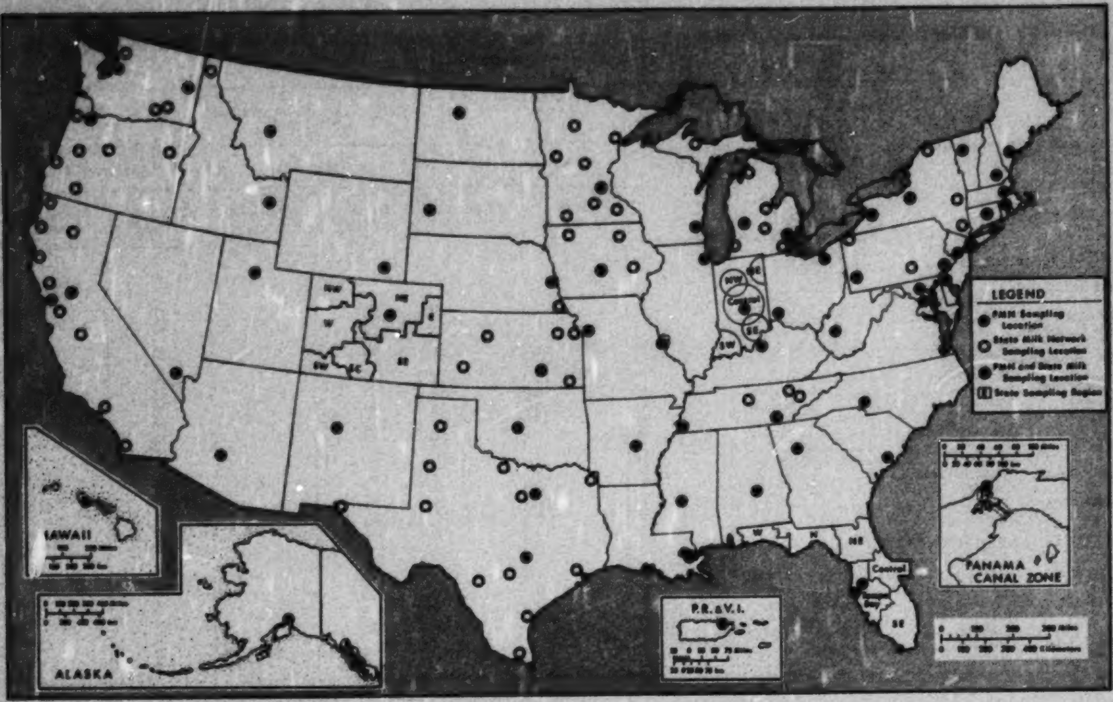

Figure 2. State and PMN milk sampling locations in the United States

for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90, iodine-131, and cesium-137 for March 1971 and the 12-month period, April 1970 to March 1971. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for March 1971 were below the respective practical reporting levels. The following station average reflects a sample in which strontium-89 was detected: California, Del Norte, 27 pCi/liter; Sacramento, 11 pCi/liter.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower guide levels established by the Federal Radiation Council, levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 18 pCi/liter in the United States for March 1971, and the highest 12-month average was 16 pCi/liter (Del Norte, Calif. (State)) representing 8.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 74 pCi/liter in the United States for March 1971, and the highest 12-month average was 80 pCi/liter (Southeast Florida (State)), representing 2.2 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica. Iodine-131 results for individual samples were all below the practical reporting level, with the exception of Kansas City, Kans. (State), 14 pCi/liter.

Acknowledgment

Appreciation is expressed to the personnel of the following agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National Health
and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Nuclear Engineering
New York State Department of Environmental
Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section Division of Health
Washington Department of Social and Health
Services

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(*7*) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

(*8*) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The cause of relatively high cesium-137 concentrations in Tampa, Florida, milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January–June 1970	November 1970
Carbon-14 in Total Diet and Milk	July–December 1970	May 1971
Connecticut Standard Diet	July–December 1969	December 1970
Institutional Diet Samples	October–December 1970 and Annual Summary 1970	May 1970
Strontium-90 in Tri-City Diets, *HASL*	January–December 1969	June 1970

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SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (2–4), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	July–December 1968	August 1970
Interstate Carrier Drinking Water	1967–1969	December 1970
Kansas	January–December 1969	September 1970
Minnesota	July–December 1969	May 1971
North Carolina	January–December 1967	May 1969
New York	January–June 1969	June 1970
Radiostrontium in Tap Water, *HASL*	January–June 1970	April 1971
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	July–December 1970	May 1971
Washington	July 1968–June 1969	February 1971

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

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(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

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Interstate Carrier Drinking Water Analysis Program, 1970

Office of Water Programs and Office of Radiation Programs, Environmental Protection Agency

The routine surveillance of finished drinking water from public drinking water supplies has been a project of a division [formerly the Bureau of Water Hygiene, Public Health Service (PHS)] of the Office of Water Programs of the Environmental Protection Agency (EPA) since 1960, in partial fulfillment of the requirements as set forth in Subpart J of the Interstate Quarantine Regulation (*1*) most commonly referred to as the Public Health Service Drinking Water Standards. The basic network for this activity is the approximately 665 water supplies (serving over half of the U.S. population with access to public water systems) which provide water for use by interstate carriers. Laboratory support is provided by the Northeastern Radiological Health Laboratory of the PHS, and the Eastern Environmental Radiation Laboratory and Western Environmental Research Laboratory of EPA. For the most part, samples were composited over a 14-day period, taking 90 milliliters, three times during the operating day; however, as indicated in table 1, many samples were also taken as a single grab sample. In many cases where a water system receives raw water from more than one source, the finished drinking water derived from each source has been examined.

The drinking water standards for radionuclides are conservative in their requirements so that the total intake of these nuclides from all sources is not likely to result in an intake greater than the guidance levels given by the Federal Radiation Council (*2*).

The standards provide for the approval of water supplies, based on their radionuclide content, when the water does not contain more than 3 pCi/liter of radium-226 or 10 pCi/liter of strontium-90. In the absence of strontium-90, and in the absence of alpha emitters, the water supply is acceptable when the gross beta concentration does not exceed 1,000 pCi/liter.

However, a water supply may be approved when the limits prescribed above are exceeded if it can be demonstrated by surveillance that the total intake of radioactivity from all sources is within the guidance for control action recommended by the Federal Radiation Council. When mixtures of radionuclides are present, the relative contribution of each radionuclide to the total intake of the individual should be considered when evaluating the exposure.

Table 1 provides the results of the radiological analyses and table 2 is a summary of the results.

REFERENCES

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(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402 (September 1961).

Previous coverage in Radiological Health Data and Reports:

Period	Issue
1961–1966	August 1968
1967–1969	December 1970

Table 1. Radiological analyses of Interstate Carrier water supplies, 1970[a]

Sampling location		Sampling periods	Gross alpha radioactivity		Gross beta radioactivity		^{226}Ra	^{90}Sr
			Dissolved	Suspended	Dissolved	Suspended		
Del:	Delaware City	10/7	0 (total)		3 (total)			
	Lewes	10/6	0 (total)		0 (total)			
	Wilmington	10/7	0 (total)		3 (total)			
Fla:	Hialeah (Preston Plant)	4/23–5/7	0	0	4	0		
	Hialeah (Hialeah Plant)	4/23–5/7	0	0	4	0		
	Miami	4/22–5/6	0	0	0	0		
Ill:	Cairo	6/1–6/22	0	0	5	0		
	Carbondale	11/9	0 (total)		8 (total)			
	Des Plaines	3/20	0	0	3	0		
	Franklin Park	9/15	0 (total)		4 (total)			
	Moline	11/4	0 (total)		9 (total)			
	Rosemont	9/15	0 (total)		3 (total)			
	Savanna	6/3	5	0	9	0		
	Schiller Park	4/3	0	0	4	0	2.1	
	Wood River	11/12	0 (total)		4 (total)			
Ind:	Logansport	5/21–6/4	0	0	6	0		
	Mt. Vernon	6/30	0 (total)		7 (total)			
	Washington	6/29	0 (total)		5 (total)			
La:	Baton Rouge	2/25	0	0	0	0		
Maine:	Portland	6/30–7/13	0 (total)		6 (total)			
Nebr:	Grand Island	11/11	17 (total)		14 (total)		1.4	0
	Scottsbluff	11/10	17 (total)		20 (total)		.3	0
N.J:	Elizabeth	8/26–9/8	0 (total)		4 (total)			
	Raritan	8/27–9/10	0 (total)		3 (total)			
	Wrightstown	9/1–9/14	0 (total)		4 (total)			
		9/15	0 (total)		5 (total)			
N.Y:	Latham	10/1–10/14	0 (total)		4 (total)			
	Troy	10/1–10/15	0 (total)		5 (total)			
Ohio:	Cleveland	10/6	0 (total)		6 (total)			
		10/7	0 (total)		7 (total)			
		10/8	0 (total)		5 (total)			
		10/9	0 (total)		6 (total)			
	Hamilton	9/1–9/9	0 (total)		3 (total)			
	Lorain	11/16	0 (total)		5 (total)			
	Vandalia	9/1–9/8	0 (total)		0 (total)			
	Youngstown	11/20	0 (total)		8 (total)			
Puerto Rico:	Guaynabo	9/16–9/29	0 (total)		5 (total)			
	Loiza	9/16–9/29	0 (total)		4 (total)			
	Trujillo-Alto	9/16–9/29	0 (total)		4 (total)			
Tex:	Point Comfort	3/18	0	0	0	0		
	Corpus Christi	3/20	0	0	9	0		
		3/20	0	0	9	0		
	Ingleside	3/31	0	0	4	0		
Va:	Alexandria	3/12	0	0	4	0		
	Danville	2/3–2/17	0	0	3	0		
		2/3–2/17	0	0	0	0		
	Occoquan	3/25	0	0	8	0		
Virgin Islands:	Charlotte Amalie	9/1–9/14	0 (total)		0 (total)			
Wis:	Ashland	4/22–5/6	0	0	5	0		
	Oshkosh	4/21–5/4	0	0	0	0		

[a] The minimum detectable radioactivity is 2 pCi/liter for strontium-90, gross alpha, and gross beta radioactivity; and 0.1 pCi/liter for radium-226. All values equal to or less than the minimum detectable radioactivity are reported as zero.

Table 2. Interstate carrier drinking water analysis program, 1970 summary

Radioactivity	Number of samples	Concentration[a] (pCi/liter)	
		Average	Range
Radium-226	3	1.3	0.3–2.1
Strontium-90	2	0	0
Gross alpha:			
Dissolved	19	.3	0–5
Suspended	19	0	0
Total sample	31	1.0	0–17
Gross beta:			
Dissolved	19	4.1	0–9
Suspended	19	0	0
Total sample	31	5.3	0–20

[a] The minimum detectable radioactivity is 2 pCi/liter for strontium-90, alpha, and beta radioactivity; and 0.1 pCi/liter for radium-226. All values equal to or less than the minimum detectable radioactivity are reported as zero.

Tritium Surveillance System, January-March 1971

Office of Radiation Programs
Environmental Protection Agency

The Tritium Surveillance System is an expansion of previous tritium surveillance activities conducted by the Office of Radiation Programs, Environmental Protection Agency (EPA). The principal effort in the past by the Office of Radiation Programs related to tritium releases has been the Tritium in Surface Water Network. This network was established in 1964, to measure and monitor tritium concentrations in major river systems in the United States and to provide surveillance at surface water stations downstream from selected nuclear facilities. The network consisted of selected stations from existing water pollution sampling stations operated by the Office of Water Programs of EPA. The final data from this network for January–June 1970 were published previously (*1*).

Another effort of the Office of Radiation Programs was a tritium in precipitation program. This project was established in 1967 at selected Radiation Alert Network (RAN) stations covering the United States, including Alaska and Hawaii. The RAN is operated by the Office of Air Programs of EPA. The data from this project for July–December 1969, have been previously published (*2*). Due to the increased interest in tritium releases from nuclear facilities and the potential long-term accumulation in the environment, a

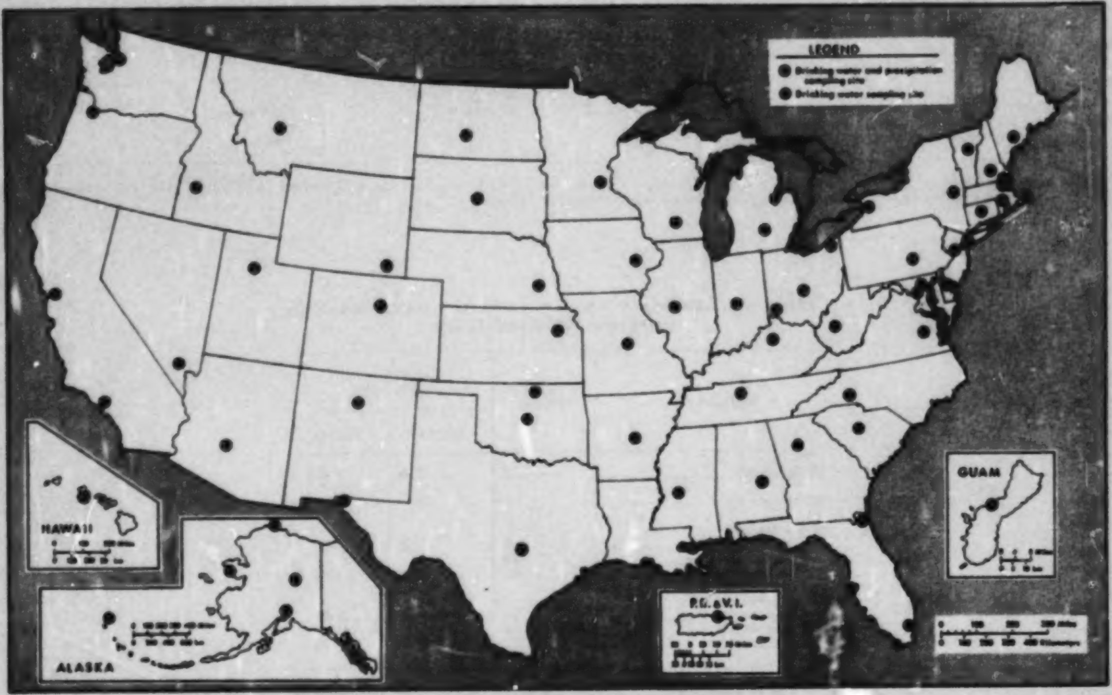
LEGEND
● Drinking water and precipitation sampling site
● Drinking water sampling site
HAWAII
ALASKA
GUAM
P.R. & V.I.

Figure 1. Drinking water and precipitation sampling locations for tritium surveillance system

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national system was established to incorporate these projects or networks into one overall system.

Present network

The Tritium Surveillance System consists of 70 quarterly drinking water samples at the RAN stations, precipitation samples collected daily and analyzed monthly from 8 of the RAN stations (figure 1), and quarterly samples at 38 surface water stations (figure 2). The specific locations for the surface water sampling system were determined by examining the water drainage areas to assure that a representative sample from a large area or region was obtained and, if possible, incorporating several nuclear facility sites. All nuclear facilities that were operating, being constructed, or planned through 1975 were considered. Consideration was also given to the current surveillance programs of the States that will be involved in the collection of the samples. The surface water samples are collected quarterly, either downstream from a nuclear facility or at a background station.

The tap water samples are collected by the RAN operators on a quarterly basis. The precipitation samples are also collected by the RAN operators on a daily basis.

All samples are sent to one of the EPA laboratories for analysis. Due to the different sensitivity of procedures used by the three laboratories, the minimum detectable concentration varies. Analytical values which are not statistically significant at the 2-sigma confidence level have been reported as zero.

Results and discussion

Table 1 presents the tritium concentrations in drinking water at the RAN stations for January–March 1971. The average tritium concentration was 0.2 nCi/liter.

Table 1. Tritium concentration in tap water (RAN stations) January–March 1971

Location		Date collected (1971)	Tritium concentration (nCi/liter ±2σ)
Ala:	Montgomery	2/1	[a]0
Alaska:	Anchorage	3/1	.6±.4
	Attu Island	1/7	0
	Fairbanks	1/7	0
	Juneau	1/26	0
	Kodiak	1/5	.4±.4
	Nome	1/7	0
	Point Barrow	1/14	1.2±.4
Ariz:	Phoenix	NS	
Ark:	Little Rock	1/26	[a]0
Calif:	Berkeley	1/5	0
	Los Angeles	1/4	0
C.Z:	Ancon	2/16	[a]0
Colo:	Denver	2/11	1.0±.4
Conn:	Hartford	1/11	.5±.4
Del:	Dover	1/11	0
D.C:	Washington	1/5	[a]0
Fla:	Jacksonville	1/22	[a]0
	Miami	1/25	[a]0
Ga:	Atlanta	2/1	[a]0
Guam:	Agana	1/4	0
Hawaii:	Honolulu	1/11	0
Idaho:	Boise	1/7	0
Ill:	Springfield	1/10	0
Ind:	Indianapolis	1/14	0
Iowa:	Iowa City	1/25	.9±.4
Kans:	Topeka	1/13	0
Ky:	Frankfort	1/25	[a]0
La:	New Orleans	1/22	[a]0
Maine:	Augusta	1/5	0
Md:	Baltimore	1/25	[a]0
Mass:	Lawrence	1/5	0
	Winchester	1/5	0
Mich:	Lansing	2/5	0
Minn:	Minneapolis	1/5	1.0±.4
Miss:	Jackson	1/25	[a]0
Mo:	Jefferson City	1/5	0
Mont:	Helena	1/5	1.0±.4
Nebr:	Lincoln	1/6	0
Nev:	Las Vegas	1/6	0
N.H:	Concord	1/11	.5±.4
N.J:	Trenton	1/11	0
N. Mex:	Sante Fe	NS	
N.Y:	Albany	1/1	0
	Buffalo	1/11	0
	New York City	1/29	0
N.C:	Gastonia	1/26	[a]0
N. Dak:	Bismarck	2/8	1.1±.4
Ohio:	Cincinnati	1/22	0
	Columbus	1/5	0
	Painesville	1/5	0
Okla:	Oklahoma City	1/25	[a]0
	Ponca City	1/25	[a]0
Oreg:	Portland	NS	
Pa:	Harrisburg	1/5	0
P.R:	San Juan	2/18	[a]0
R.I:	Providence	1/6	0
S.C:	Columbia	1/8	[a]0
S. Dak:	Pierre	1/7	1.3±.4
Tenn:	Nashville	1/26	[a]0
Tex:	Austin	1/27	[a]0
	El Paso	1/26	[a]0
Utah:	Salt Lake City	1/4	.5±.4
Vt:	Barre	1/4	0
Va:	Richmond	1/31	[a]0
Wash:	Seattle	NS	
	Spokane	1/8	0
W. Va:	Charleston	1/28	[a]0
Wisc:	Madison	1/21	0
Wyo:	Cheyenne	1/4	1.7±.4
Network average			0.2

[a] The minimum detection limit for this sample was 0.2 nCi/liter. All values equal to or less than 0.2 nCi/liter have been reported as zero. For all other zero numbers and for the calculation of the network average, the minimum detection limit was 0.4 nCi/liter and all values equal to or less than 0.4 nCi/liter have been reported as zero.

NS, no sample.

The radiation dose resulting from the observed tritium concentrations in the drinking water may be evaluated by using the relationship derived by Moghissi and Porter (*3*) from recommendations of the International Commission of Radiological Units and Measurements (*4*). Assuming that the concentration of tritium in all water taken into the body is equal to that found in the drinking water and also that the specific activity of tritium

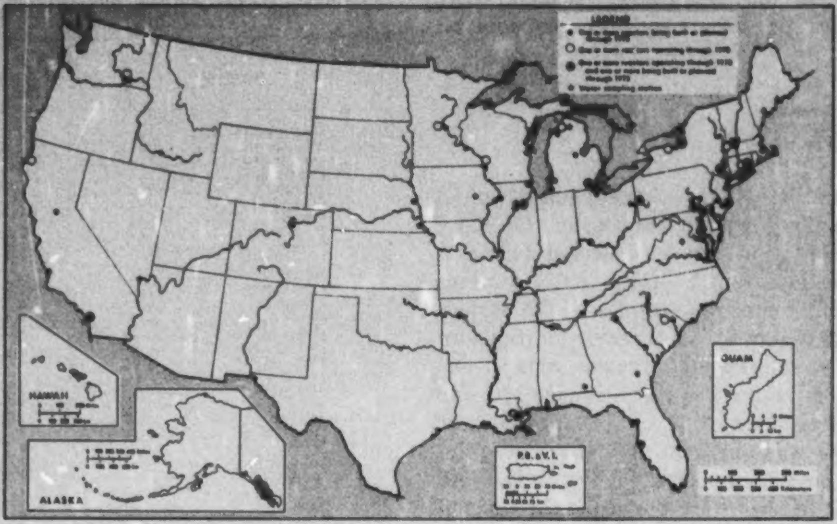

Figure 2. Surface water sampling locations for tritium surveillance system

Table 2. Tritium concentration in surface water, January–March 1971

Location		Water source	Facility	Collection date (1971)	Concentration (nCi/liter ± 2σ)
Ala:	Decatur	Tennessee River	Browns Ferry	1/14	[a]0
Ark:	Morrilton	Arkansas River	Arkansas Nuclear	1/14	[a]0
Calif:	Eureka	Humboldt Bay	Humboldt Bay	1/28	0
	San Onofre	Pacific Ocean	San Onofre	3/4	0
Colo:	Greely	South Platte River	Fort St. Vrain	2/12	1.0±.4
Conn:	East Haddam	Connecticut River	Connecticut Yankee & Vermont Yankee	1/28	.6±.4
	Waterford	Long Island Sound	Millstone	1/28	.5±.4
Fla:	Crystal River	Gulf of Mexico	Crystal River	1/12	[a]0
	Key Largo	Biscayne Bay	Turkey Point	1/17	.3±.2
Idaho:	Buhl	Snake River	National Reactor Testing Station	1/7	0
Ill:	Moline	Mississippi River	Quad-Cities	1/20	0
	Morris	Illinois River	Dresden and Argonne	1/19	0
La:	New Orleans	Mississippi River	(Several)	1/14	[a]0
Md:	Conowingo	Susquehanna River	Peach Bottom and Three Mile Island	2/17	0
	Lusby	Chesapeake Bay	Calvert Cliffs	NS	
Mass:	Rowe	Deerfield River	Yankee	1/25	2.9±.4
Mich:	Charlevoix	Lake Michigan	Big Rock Point	3/21	0
	Monroe	Lake Erie	Enrico Fermi	3/15	0
	South Haven	Lake Michigan	Palisades	3/22	0
Minn:	Monticello	Mississippi River	Monticello	1/5	1.0±.4
Nebr:	Rulo	Missouri River	Fort Calhoun and Cooper	1/20	1.3±.4
Nev:	Boulder City	Colorado River	Background	NS	
N.J:	Bayside	Delaware River	Salem	NS	
N.Y:	Ossining	Hudson River	Indian Point	1/18	0
	Oswego	Lake Ontario	Nine Mile Point and R. E. Ginna	3/12	0
	Poughkeepsie	Hudson River	Background	1/13	0
N.C:	Charlotte	Catawba River	Wm. B. McGuire	1/14	[a]0
S.C:	Allendale	Savannah River	Savannah River Plant and Oconee	1/27	2.4±.2
	Hartsville	Lake Robinson	H. B. Robinson	3/10	.3±.2
Tenn:	Kingston	Clinch River	Oak Ridge	1/12	3.7±.2
Tex:	El Paso	Rio Grande	Los Alamos	1/11	.4±.4
Vt:	Vernon	Connecticut River	Vermont Yankee	1/4	.6±.4
Va:	Surry	James River	Surry	1/22	[a]0
Wash:	Northport	Columbia River	Background	2/10	.8±.4
	Pasco	Columbia River	Hanford	1/15	.9±.4
W.Va:	Wheeling	Ohio River	Shippingport	1/7	.5±.4
Wisc:	Two Creeks	Lake Michigan	Point Beach and Kewaunee	1/15	0
	Victory	Mississippi River	LaCrosse and Prairie Island	3/11	0
Network average					0.5

[a] The minimum detection limit for this sample was 0.2 nCi/liter. All values equal to or less than 0.2 nCi/liter have been reported as zero. For all other zero numbers and for the calculation of the network average, the minimum detection limit was 0.4 nCi/liter and all values equal to or less than 0.4 nCi/liter have been reported as zero.

NS, no sample.

in the body is essentially the same as that in the drinking water, then the radiation dose may be estimated.

The highest individual concentration of tritium observed in the drinking water was 1.7 nCi/liter during the first quarter. This corresponds to a dose of 0.3 mrem/a, or less than 0.2 percent of the Federal Radiation Council's Radiation Protection Guide (170 mrem/a) for an average dose to a suitable sample of the exposed population.

The tritium concentrations for the surface water samples are given in table 2. The highest tritium concentration was 3.7 nCi/liter for the first quarter. Assuming that the specific activity of tritium in the body is essentially the same as that in surface water, this concentration corresponds to a dose of 0.6 mrem/a, or 0.4 percent of the Radiation Protection Guide.

The monthly analyses for tritium in precipitation samples at the eight RAN stations are shown in table 3.

Other coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1970	May 1971

Table 3. Tritium concentrations in precipitation from RAN stations, January–March 1971

Location	Tritium concentration[a] (nCi/liter ± 2σ)		
	January	February	March
Alaska: Anchorage	NS	0.4±0.2	0.5±0.2
Ala: Montgomery	0	0	0
Colo: Denver	0	.5± .2	.8± .2
Hawaii: Honolulu	0	0	.3± .2
La: New Orleans	0	0	0
N.C: Gastonia	0	0	0
Tex: Austin	NS	NS	NS
Wash: Seattle	0	0	.3± .2

[a] The minimum detection limit for these samples was 0.2 nCi/liter. All values equal to or less than 0.2 nCi/liter have been reported as zero. NS, no sample.

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(3) MOGHISSI, A. A. and C. R. PORTER. Tritium in surface waters in the United States, 1966. Radiol Health Data Rep 9:337–339 (July 1968).

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	July–December 1968 and January–December 1969	January 1971
Plutonium in Airborne Particulates and Precipitation	July–December 1970	June 1971
Surface Air Sampling Program, 80th Meridian Network, *HASL*	January–December 1968	April 1971

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1. Radiation Alert Network March 1971

Office of Air Programs
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State Health Department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the short-lived radon daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Data Acquisition and Analysis Branch, Office of Air Programs, EPA, Cincinnati, Ohio. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during March 1971. All field estimates reported were within normal limits for the reporting station.

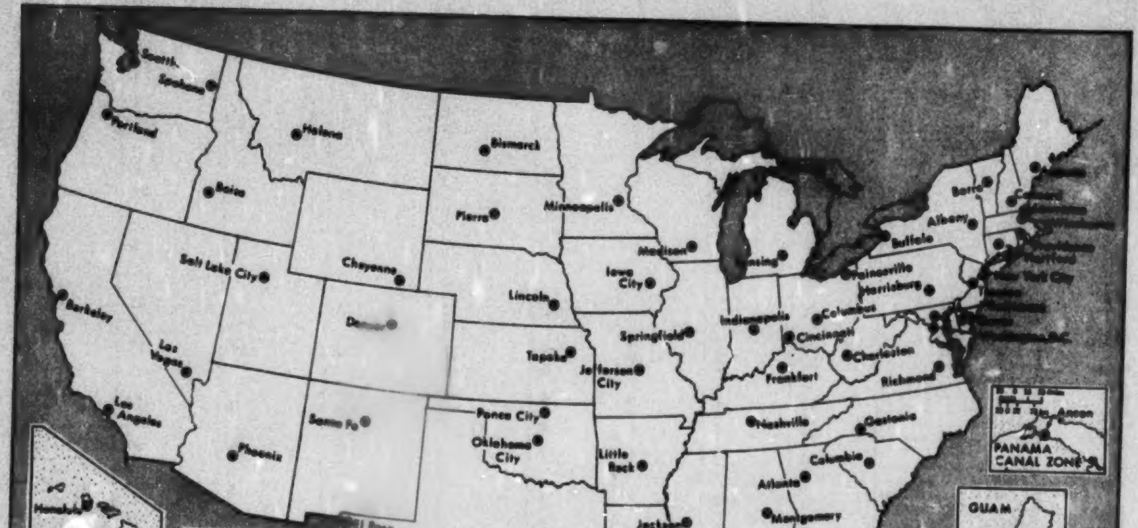
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
Cheyenne
Madison
Lansing
Buffalo
Albany
Barre
Berkeley
Lincoln
Iowa City
Denver
Harrisburg
New York City
Las Vegas
Springfield
Indianapolis
Columbus
Cincinnati
Topeka
Jefferson City
Charleston
Frankfort
Richmond
Washington, D.C.
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Nashville
Gastonia
Phoenix
Little Rock
Columbia
Atlanta
Montgomery
Jackson
El Paso
Austin
New Orleans
Jacksonville
Miami
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Juneau
Kodiak
ALASKA
P.R. & V.I.
San Juan
GUAM
Agana
PANAMA CANAL ZONE
Ancon

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, March 1971

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Precipitation				
						Number of samples	Total depth (mm)	Field estimation of deposition		
			Maximum	Minimum	Average[a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	23	2	0	1	9	456	9	456	186
Alaska:	Anchorage	3	0	0	0	0				
	Attu Island	24	0	0	0	0				
	Fairbanks	0				0				
	Juneau	7	16	1	3	2	15	2	15	0
	Kodiak	12	0	0	0	0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	12	9	2	4	0				
Ark:	Little Rock	13	2	0	0	0				
Calif:	Berkeley	23	1	0	0	4	72	4	72	0
	Los Angeles	23	4	0	1	0				
C.Z:	Ancon	5	0	0	0	0				
Colo:	Denver	23	7	1	2	2	25	(a)		
Conn:	Hartford	23	0	0	0	7	91	7	91	4
Del:	Dover	23	1	0	0	0				
D.C:	Washington	27	1	0	0	0				
Fla:	Jacksonville	22	2	0	1	4	68	4	68	13
	Miami	21	1	0	0	0				
Ga:	Atlanta	20	2	1	1	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	26	1	0	0	5	76	(b)		
Idaho:	Boise	22	2	0	1	7	41	7	41	5
Ill:	Springfield	4	1	0	1	0				
Ind:	Indianapolis	22	1	0	0	0				
Iowa:	Iowa City	20	2	0	0	3	10	3	10	3
Kans:	Topeka	23	3	0	1	3	17	3	17	1
Ky:	Frankfort	0				0				
La:	New Orleans	20	1	0	0	9	133	(b)		
Maine:	Augusta	23	1	0	0	6	88	6	88	3
Md:	Baltimore	22	2	0	0	5	40	5	40	0
Mass:	Lawrence	23	1	0	0	4	45	4	45	0
	Winchester	23	1	0	0	7	70	7	70	0
Mich:	Lansing	21	1	0	0	0				
Minn:	Minneapolis	23	1	0	0	2	35	2	35	5
Miss:	Jackson	21	1	0	0	9	357	9	357	25
Mo:	Jefferson City	23	3	0	1	2	23	2	23	0
Mont:	Helena	21	2	0	1	1	3	1	3	3
Nebr:	Lincoln	23	5	0	1	3	66	3	66	30
Nev:	Las Vegas	21	4	0	2	0				
N.H:	Concord	0				0				
N.J:	Trenton	23	1	0	0	8	104	8	104	9
N.Mex:	Santa Fe	11	1	0	0	0				
N.Y:	Albany	15	0	0	0	4	25	4	25	12
	Buffalo	22	1	0	0	0				
	New York City	0				0				
N.C:	Gastonia	18	5	0	2	6	56	(b)		
N.Dak:	Bismarck	23	1	0	0	2	4	2	4	0
Ohio:	Cincinnati	0				0				
	Columbus	0				0				
	Painesville	23	1	0	1	7	31	7	31	7
Okla:	Oklahoma City	0				0				
	Ponca City	23	11	0	2	0				
Oreg:	Portland	20	0	0	0	17	192	16	177	10
Pa:	Harrisburg	9	0	0	0	0				
P.R:	San Juan	0				0				
R.I:	Providence	20	1	0	0	0				
S.C:	Columbia	19	3	0	1	9	154	9	154	20
S.Dak:	Pierre	23	6	0	1	0				
Tenn:	Nashville	22	1	0	1	9	87	9	87	7
Tex:	Austin	0				0				
	El Paso	0				0				
Utah:	Salt Lake City	31	2	0	1	7	16	6	14	1
Vt:	Barre	0				0				
Va:	Richmond	22	1	0	0	7	71	7	71	45
Wash:	Seattle	10	0	0	0	10	138	(b)		
	Spokane	17	1	0	1	0				
W.Va:	Charleston	23	3	0	1	11	53	10	44	5
Wisc:	Madison	23	1	0	0	4	40	4	40	8
Wyo:	Cheyenne	23	4	0	1	3	25	3	25	1
Network summary		1,104	16	0	1	198	94	6	78	14

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the plutonium in precipitation network. No gross beta measurements are done.

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2. Canadian Air and Precipitation Monitoring Program,[1] March 1971

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for January 1971 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, March 1971

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	5	0.1	0.1	0.1	33	0.88
Coral Harbour	5	.1	.1	.1	111	.70
Edmonton	5	.2	.1	.2	26	.50
Ft. Churchill	4	.1	.1	.1	215	.44
Fredericton	5	.2	.0	.1	19	2.35
Goose Bay	5	.1	.0	.1	7	.09
Halifax	18	.3	.1	.2	53	6.98
Inuvik	5	.1	.1	.1	NA	NA
Montreal	5	.1	.1	.1	49	3.40
Moosonee	5	.2	.1	.1	26	.18
Ottawa	5	.2	.1	.1	29	1.09
Quebec	5	.2	.1	.1	12	1.13
Regina	5	.2	.1	.1	51	1.10
Resolute	5	.2	.1	.1	[a]33	[a].14
St. John's, Nfld	5	.2	.1	.1	86	8.08
Saskatoon	5	.1	.1	.1	29	.61
Sault Ste. Marie	5	.2	.1	.2	65	3.95
Thunder Bay	5	.2	.1	.1	65	3.53
Toronto	5	.1	.1	.1	75	2.93
Vancouver	5	.2	.1	.1	54	8.53
Whitehorse	5	.2	.1	.1	14	.15
Windsor	5	.1	.1	.1	33	1.61
Winnipeg	4	.1	.1	.1	53	2.32
Yellowknife	5	.1	.1	.1	22	.30
Network summary	131	0.3	0.0	0.1	50	2.30

[a] Analysis covers period from February 1 to March 31.
NA, no analysis.

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

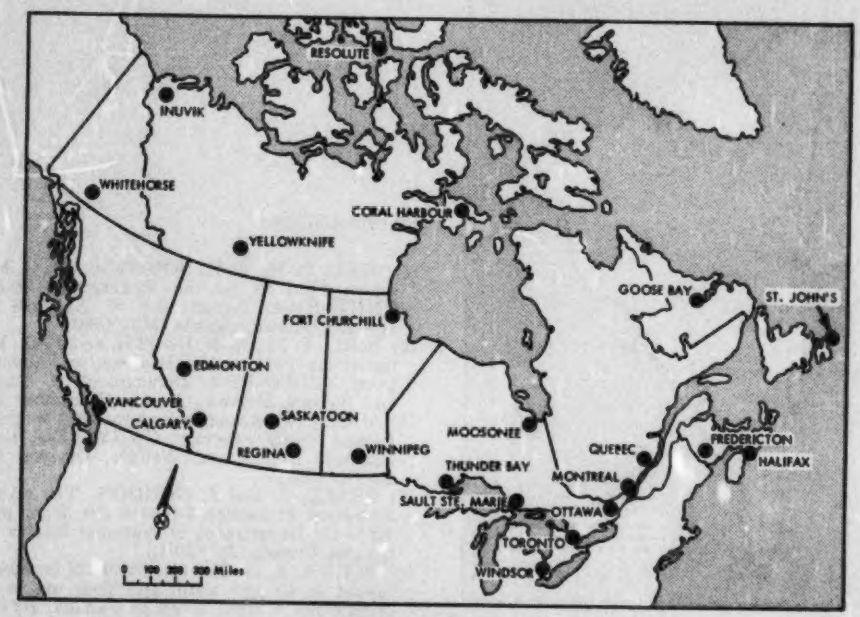
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
0 100 200 300 Miles

Figure 2. Canadian air and precipitation sampling stations

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3. Pan American Air Sampling Program March 1971

Pan American Health Organization and
Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The March 1971 air monitoring results from the participating countries are given in table 3.

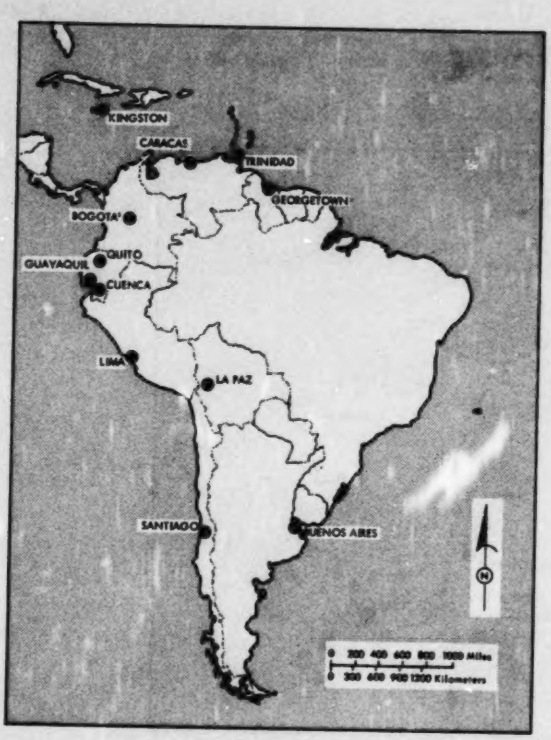

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, March 1971

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	NS			
Bolivia:	La Paz	18	0.09	0.00	0.03
Chile:	Santiago	30	.73	.05	.18
Colombia:	Bogota	22	.08	.01	.04
Ecuador:	Cuenca	NS			
	Guayaquil	NS			
	Quito	NS			
Guyana:	Georgetown	12	.63	.09	.25
Jamaica:	Kingston	NS			
Peru:	Lima	23	.16	.04	.08
Venezuela:	Caracas	5	.45	.14	.27
West Indies:	Trinidad	18	.80	.05	.37
Pan American summary		128	0.80	0.00	0.15

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
NS, no sample.

REFERENCES

(1) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

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(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follows for the Savannah River Plant.

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[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Savannah River Plant: January–June 1970

E. I. duPont de Nemours
Aiken, S.C.

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. duPont de Nemours and Company, occupies an area of 312 square miles along the Savannah River, 22 miles downstream from Augusta, Ga. Production facilities include a fuel preparation area, three reactors, two fuel separation areas, and a heavy water production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to ensure environmental concentrations below recommended guides.

A continuous monitoring program has been maintained since 1951 (before plant startup) to determine the concentrations of radioactive materials in a 1,200 square-mile area outside the plant. Included in this area are parts of Aiken, Barnwell, and Allendale counties in South Carolina, and Richmond, Burke, and Screven counties in Georgia. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the AEC radiation protection standards as given in the AEC Manual.

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Plant-released radioactivity and atmospheric fallout are included in the reported concentrations. Maximum and minimum values given are for individual samples collected during January–June 1970.

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by biweekly analyses of air filters collected at five monitoring stations near the plant perimeter and 10 stations around a

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[2] Summarized from "Effect of the Savannah River Plant on Environmental Radioactivity, Semiannual Report, January–June 1970" (DPST-10-30-2).

circle of about a 25-mile radius from the center of the plant (figure 1). Deposition rates of radioactive material at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant release of airborne radioactivity by SRP would be detected regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Ga., and at Columbia and Greenville, S.C., are so distant from SRP that the effect of SRP operations is negligible; they serve as reference points for determining background radioactivity levels (figure 2). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between fallout and SRP releases.

The small amount of filterable beta radioactivity released to the atmosphere, primarily from the fuel separation areas, was obscured by fallout. The influence of nuclear tests, which resumed in September 1961, is shown in figure 3. The present low levels of atmospheric activity are attributed to the moratorium on above-ground nuclear tests, which began in 1962. The observed spring increases are anticipated and result primarily from the mixing of the stratospheric debris into the troposphere. The average beta concentration in air increased from 0.15 pCi/m^3 to 0.26 pCi/m^3 during the first half of 1970. Gamma-emitting radionuclides in fallout were cesium-134, -137, cerium-141, -144, ruthenium-103, -106, and zirconium-niobium-95.

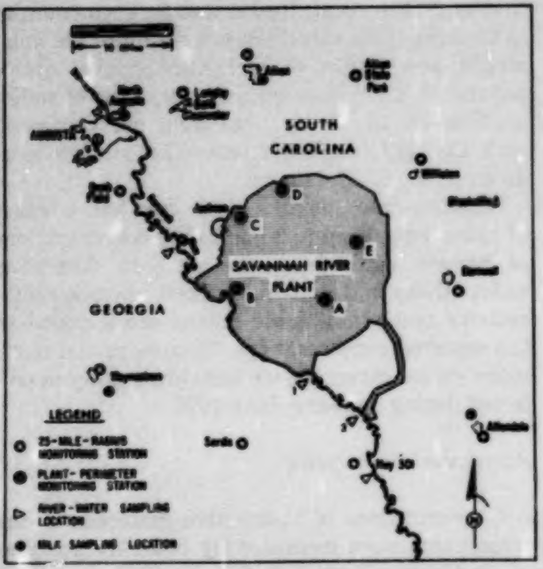
10 miles
AUGUSTA
SOUTH
CAROLINA
GEORGIA
SAVANNAH RIVER
PLANT
A
B
C
D
E
1
2
Sardis
Hwy 301
LEGEND
25-MILE-RADIUS MONITORING STATION
PLANT-PERIMETER MONITORING STATION
RIVER-WATER SAMPLING LOCATION
MILK SAMPLING LOCATION

Figure 1. Environmental sampling locations, Savannah River Plant

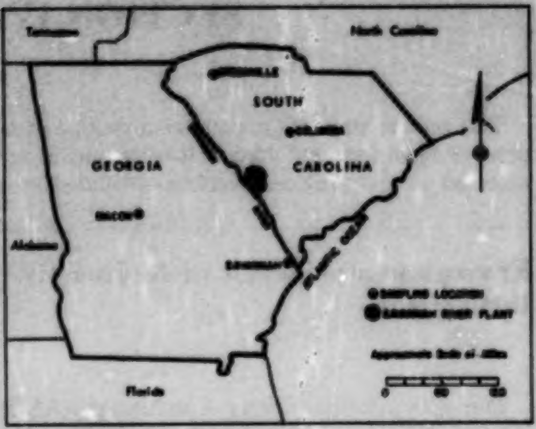
Tennessee
North Carolina
GREENVILLE
SOUTH
COLUMBIA
CAROLINA
GEORGIA
MACON
Alabama
SAVANNAH
ATLANTIC OCEAN
Florida
SAMPLING LOCATION
SAVANNAH RIVER PLANT
Approximate Scale of Miles
0
60
120

Figure 2. Distant air monitoring stations, Savannah River Plant

Short radioactive half-life barium-lanthanum-140, neptunium-239, and iodine-131 in routine air samples were less than the level of detection throughout the period. The major component, beryllium-7, is a naturally occurring radionuclide formed by interaction of cosmic rays with oxygen and nitrogen in the upper atmosphere. Radioactivity in air, determined from filter analyses, is shown in table 1. The January-June 1970 concentrations of filterable beta radioactivity (0.26 pCi/m^3) and alpha radioactivity (1.1 fCi/m^3) in air were 0.26 and 1.6 percent of the respective AEC standards. Tritium oxide concentrations in air, at the plant perimeter and at the 25-mile stations, did not exceed 0.2 percent of the AEC standard.

Deposition of fallout during January–June 1970 averaged 13 nCi/m^2 at the plant perimeter locations and 12 nCi/m^2 at the 25-mile radius locations; comparable values for the last half of 1969 were 7 and 8 nCi/m^2 (excluding naturally occurring beryllium-7). Deposition at each sampling location is presented in table 2.

Table 1. Radioactivity in air, Savannah River Plant, January–June 1970

Sampling points	Alpha radioactivity^a (fCi/m³)			Nonvolatile beta radioactivity^b (pCi/m³)			Specific radionuclides in composite samples (pCi/m³)					
	Maximum	Minimum	Average	Maximum	Minimum	Average	^{90}Sr	^{137}Cs	^{141,144}Ce	^{103,106}Ru	^{95}Zr-Nb	^{7}Be
Plant perimeter:												
A	2.8	0.2	0.8	0.30	0.07	0.20						
B	2.4	.5	1.3	.25	.09	.22						
C	2.9	.3	1.0	.25	.04	.27	0.010	0.01	0.07	0.07	0.14	0.18
D	1.7	ND	.9	.33	.05	.23						
E	2.8	.6	1.2	.34	.06	.20						
Average			1.0			0.23						
20-mile radius:												
Aiken Airport	2.4	.5	1.1	.62	.07	.27						
Aiken State Park	5.6	ND	1.9	.58	.05	.25						
Allendale	5.8	.4	1.7	.68	.06	.25						
Barnwell	6.4	.5	1.8	.60	.05	.25						
Bush Field	6.6	.3	1.8	.51	.06	.24	.012	.01	.08	.08	.12	.17
Langley	7.8	.6	2.4	.58	.05	.23						
Sardis	3.7	.3	1.4	.55	.04	.23						
Waynesboro	5.6	.4	1.9	.60	.05	.20						
Williston	4.3	.5	1.8	.47	.05	.22						
Highway 301	3.0	ND	1.5	.50	.04	.22						
Average			1.7			0.26						
Distant air-monitoring:												
S.C.												
Columbia	1.5	0.3	0.9	0.20	0.03	0.19						
Greenville	1.3	ND	.8	.56	.06	.29						
Ga.												
Macon	1.4	ND	.8	.61	.04	.28	.014	.01	.06	.05	.12	.17
Savannah	1.9	ND	.6	.54	.05	.27						
Average			0.8			0.23						

[a] AEC radiation protection standard-70 fCi/m³.
[b] AEC radiation protection standard-100 pCi/m³.
ND, nondetectable

Table 2. Total fallout deposited, Savannah River Plant, January–June 1970

Sampling points	Radioactivity (nCi/m²)						
	Alpha^a	Strontium-89	Strontium-90	Cesium-137	Cerium-141, 144	Zirconium-niobium-95	Beryllium-7^b
Plant perimeter:							
A	3.4	1.7	0.7	1.3	5.8	9.6	19.1
B	2.5	.4	.5	.7	2.5	1.9	9.4
C	5.9	1.6	.5	.9	4.9	4.0	14.6
D	3.5	1.0	.5	1.1	5.8	7.3	23.7
E	4.6	1.3	.5	.9	4.2	[illegible]	11.3
Average	4.1	1.1	0.5	1.0	4.6	5.8	15.6
20-mile radius:							
Aiken Airport	2.7	1.2	.5	.9	4.0	4.9	19.3
Aiken State Park	3.1	.7	.7	.9	3.2	4.3	10.7
Allendale	2.6	1.1	1.0	1.0	5.0	6.1	17.5
Barnwell	1.7	.5	.3	.7	2.5	3.9	10.6
Bush Field	2.0	.4	.7	.9	4.6	6.4	15.8
Langley	5.3	1.7	.9	1.2	4.7	6.9	18.9
Sardis	3.4	1.2	.5	1.4	4.6	9.2	19.9
Waynesboro	3.5	1.6	.7	1.2	5.0	7.3	14.1
Williston	2.0	.6	.3	.7	2.0	3.2	9.8
Highway 301	3.3	1.5	.7	1.2	5.9	8.1	15.4
Average	3.0	1.1	0.7	1.0	3.7	6.1	15.2

[a] Multiple by 10^{-3}.
[b] A naturally-occurring radionuclide.

Water monitoring

The plant site is drained by five streams that flow several miles through the reservation before reaching the river (figure 4). The primary sources of the very small amount of radioactivity that reaches the river are the reactor facilities. The reactors are cooled and moderated by heavy water which, in turn, is cooled by river water in heat exchangers. This arrangement prevents irradia-

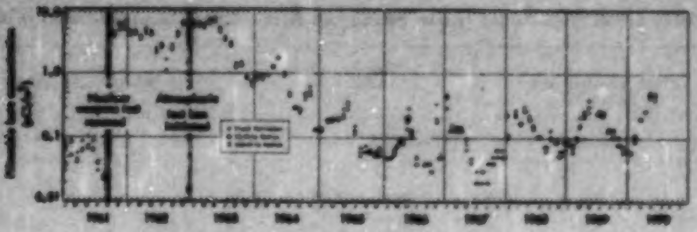

Figure 3. Influence of weapons tests

tion of the river water so that radioactivity is discharged into the river water only on the rare occasions when small quantities of moderator are lost by heat-exchanger leaks.

The irradiated fuel (canned to prevent leaching of radionuclides) discharged from a reactor is stored in a large, water-filled basin that is purged to maintain clarity and to control water temperature. Newly discharged fuel is placed into an isolated section of the basin equipped with a water-

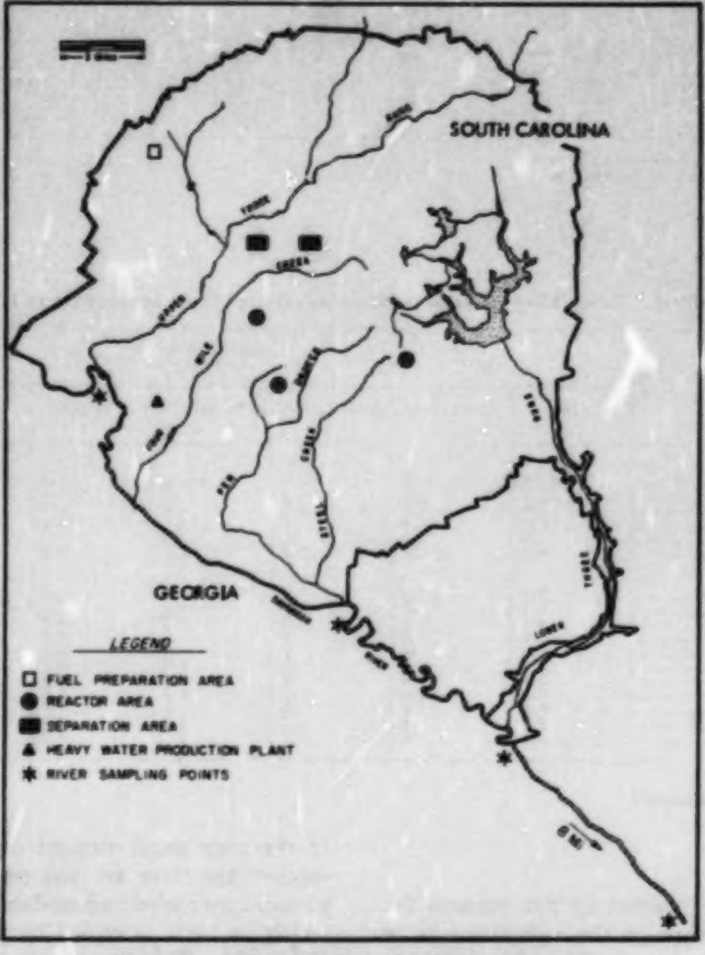
SOUTH CAROLINA
GEORGIA
LEGEND
☐ FUEL PREPARATION AREA
● REACTOR AREA
▬ SEPARATION AREA
▲ HEAVY WATER PRODUCTION PLANT
✱ RIVER SAMPLING POINTS

Figure 4. SRP production and effluent streams

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circulating system. Portable filters and deionizers are provided to remove a large percentage of the radionuclides, and a heat exchanger is used to control basin water temperature. Tritium from the irradiation of the D_2O moderator accounts for the largest quantity of radioactivity released by the reactors to the environment. However, the contribution to the Savannah River results in concentrations less than 1 percent of the AEC standard.

In January 1965, the Beaufort-Jasper Water Authority began operation of a treatment facility to furnish sanitary water, partially supplied from the Savannah River, to most of Beaufort County, S.C. Water is supplied through a canal from the river at a location about 90 miles below the Savannah River Plant. The city of Savannah also supplements its domestic well water supply with river water during periods of peak demand. The tritium concentrations in raw water collected from the Beaufort-Jasper Water Plant averaged 1.7 nCi/liter (0.06 percent of the AEC standard) during January–June 1970. The annual radiation exposure of an individual in this population due to the consumption of 1.2 liters per day of water containing the very low concentration of tritium is 0.16 mrem, (this exposure may be compared with 20 mrem per year from natural potassium found in the body of all persons or with the 170 mrem per year specified by the Federal Radiation Council as the annual dose guide for members of the public).

Communities near the plant get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns were collected and analyzed in April. There was no evidence that SRP contributed radioactivity to drinking water supplies; concentrations of alpha radioactivity (1.1 pCi/liter) and beta radioactivity (6 pCi/liter) were essentially the same as those observed before plant startup. Radioactivity data in public water supplies are presented in table 3.

Table 3. Radioactivity in public water supplies January–June 1970

Sampling points	Alpha radioactivity[a] (pCi/liter)	Nonvolatile beta radioactivity[b] (pCi/liter)
	April	April
Aiken	0.9	ND
Allendale	.7	8
Augusta	.3	ND
Barnwell	.5	6
Bath	1.6	ND
Blackville	.2	ND
Clearwater	ND	ND
Jackson	6.8	18
Langley	1.3	ND
New Ellenton	.3	4
North Augusta	.3	ND
Sardis	.4	4
Waynesboro	.3	4
Williston	1.5	7
Average	1.1	6

[a] AEC radiation protection standard—10 pCi/liter; sensitivity of analysis—0.2 pCi/liter.

[b] AEC radiation protection standard—3 nCi/liter; sensitivity of analysis—4.0 pCi/liter.

ND, nondetectable.

River water, analyzed weekly, was sampled continuously at four locations, as shown in figure 4. Concentrations of alpha and nonvolatile beta radioactivity in river water for the past year are presented in table 4. Average concentrations of specific radionuclides found in river water during January–June 1970 appear in table 5.

Table 4. Radioactivity in Savannah River water, January–June 1970

Sampling point	Alpha radioactivity[a] (pCi/liter)				Nonvolatile beta radioactivity[b] (pCi/liter)			
	January–June 1970			July–December 1969	January–June 1970			July–December 1969
	Maximum	Minimum	Average	Average	Maximum	Minimum	Average	Average
1 mile upstream from Upper Three Runs Creek (control)	0.5	ND	ND	ND	8	ND	ND	4
Downstream from Steel Creek	.4	ND	ND	ND	11	ND	4	6
Downstream from Lower Three Runs Creek	.4	ND	ND	ND	16	ND	8	8
8 miles downstream from Lower Three Runs Creek	.6	ND	ND	ND	15	ND	6	7

[a] AEC radiation protection standard—10 pCi/liter; sensitivity of analysis—0.2 pCi/liter.

[b] AEC radiation protection standard—3 nCi/liter; sensitivity of analysis—4.0 pCi/liter.

ND, nondetectable.

Table 5. Average concentration of radionuclides in Savannah River water, January–June 1970

Radionuclide	Concentration (pCi/liter)			
	Sensitivity of analysis	Control (1 mile upstream from Upper Three Runs Creek)	Highway 301 (8 miles downstream from Lower Three Runs Creek)	Percent AEC standard at Highway 301
Tritium	600	750	5,000	0.19
Ruthenium-103, -106	3.2	ND	ND	<.03
Cerium-141, -144	2.5	ND	ND	<.02
Cesium-134, -137	.6	ND	.5	.008
Neptunium-239	2.2	ND	ND	<.003
Barium-lanthanum-140	1.6	ND	ND	<.01
Zirconium-niobium-95	.5	ND	ND	<.001
Chromium-51	4.3	ND	ND	<.001
Strontium-89	.3	ND	1.3	.04
Iodine-131	.2	ND	ND	<.07
Strontium-90	.01	.7	1.1	.37
Cobalt-60	1.4	ND	ND	<.006
Zinc-65	1.1	ND	ND	<.001
Manganese-54	.4	ND	ND	<.0004
Sulfur-35	5.0	ND	5.8	.01

ND, nondetectable, less than sensitivity of analysis.

Tritium, sulfur-35, and trace amounts of cesium-137, strontium-89, and strontium-90 were the radionuclides of SRP origin detectable in river water at the downstream location. Strontium-90 and tritium from worldwide fallout were also detected in river upstream from SRP effluents.

Tritium, a beta-particle emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavy water moderator in the reactors. Tritium is among the least dangerous of all radionuclides because it does not concentrate in body tissues. The concentration of tritium in river water averaged 0.19 percent of the AEC standard.

Fish in Savannah River

Fish, predominantly bream, were collected weekly upstream, adjacent to, and downstream from the Savannah River Plant effluents. Specific radionuclide analyses of fish are summarized in table 6. The radioactivity in bone and flesh from fish collected adjacent to and downstream from SRP indicates some minor contribution by SRP. Although measurably higher than similar collections at the control station upstream from SRP effluents, the increase is of minor significance when referenced against intake guides defined by the AEC radiation protection standard.

Table 6. Radioactivity in Savannah River fish January–June 1970

Location	Type of sample[a]	Concentration (pCi/g wet weight)			
		Strontium-89, 90		Cesium-137	
		Maximum	Average	Maximum	Average
Above plant boundary (Control)	Bone	16	7	<2	<2
	Flesh	1	<1	<1	<1
Adjacent to plant	Bone	26	14	<2	<2
	Flesh	1	<1	3	2
Below plant at Highway 301	Bone	27	14	<2	<2
	Flesh	1	<1	2	2

[a] Monthly composites of weekly collections for strontium-89, -90 and cesium-137.

Vegetation

Radioactive contamination of growing plants may result from deposition on foliar surfaces or sorption of radioactive materials from the soil.

Grass samples were collected at seven locations along the plant perimeter and at seven other locations along a 25-mile radius route (these are not designated on figure 2). Bermuda grass was selected for analysis because of its importance [illegible]

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pasture grass for dairy herds and its availability during all seasons of the year. Samples from each quadrant of the plant site and of the surrounding area were composited for monthly analysis. Gamma-emitting radionuclides in grass samples (excluding beryllium-7) were from fallout. Alpha-particle emitters averaged 0.1 pCi/g at the plant perimeter and 0.2 pCi/g at the 25-mile radius locations as compared to 0.1 pCi/g during the last half of 1969; gamma-ray emitters averaged 17.0 and 23.0 pCi/g, respectively, as compared to 12.0 and 15.3 pCi/g for the last half of 1969. Radioactivity in grass samples is presented in table 7.

Table 7. Radioactivity on vegetation, SRP January–June 1970

Radionuclides[a]	Concentration (pCi/g dry weight)			
	Plant perimeter (7 locations)		25-mile radius (7 locations)	
	Maximum	Average	Maximum	Average
Alpha emitters	0.6	0.1	0.5	0.2
Cesium-137	1.5	.9	.9	.7
Cerium-141, -144	9.7	6.1	12.6	8.3
Ruthenium-103, -106	ND	ND	ND	ND
Beryllium-7	13.1	7.7	14.1	10.9
Iodine-131	ND	ND	ND	ND
Barium-lanthanum-140	ND	ND	ND	ND
Zirconium-niobium-95	4.2	2.3	5.8	3.1

[a] Sensitivity of analysis in pCi/g dry weight, alpha emitters 0.10; cesium-137, 0.3; cerium-141, -144, 1.0; ruthenium-103, 106, 1.4; beryllium-7, 3.0; iodine-131, 0.2; barium-lanthanum-140, 6.0; zirconium-niobium-95, 0.5.

ND, nondetectable.

Milk

Milk was sampled at three dairies within a 25-mile radius of the Savannah River Plant (figure 1). Samples, collected biweekly, were analyzed for tritium and radioiodine. Strontium-90 and cesium-137 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during January–June 1970 are shown in table 8.

Average concentrations of the radionuclides in milk were 11 pCi/liter of strontium-90 and 20 pCi/liter of cesium-137 compared to 9 pCi/liter of strontium-90 and 12 pCi/liter of cesium-137 during the last half of 1969. Iodine-131 was less than the sensitivity of the analysis (5 pCi/liter) throughout this period. These values are consistent with those reported by the U.S. Public Health Service for most sections of the United States. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level (882 pCi/liter) was 0.03 percent of the AEC standard for water.

Table 8. Radioactivity in milk from local dairies Savannah River Plant, January–June 1970

Distributing points	Tritium[a] (nCi/liter)			Strontium-90[b] (pCi/liter)		Cesium-137[c] (pCi/liter)	
	Maximum	Minimum	Average	March	June	March	June
Aiken	1	ND	0.4	9	12	14	21
North Augusta	2	ND	1.4	16	15	11	23
Waynesboro	2.2	ND	.8	8	NS	NS	12
Major distributors[d]	2.1	ND	.9	11	9	25	22

[a] Sensitivity of analysis—0.2 nCi/liter; AEC standard—3,000 nCi/liter.

[b] Sensitivity of analysis—1.0 pCi/liter; AEC standard—200 pCi/liter.

[c] Sensitivity of analysis—5.0 pCi/liter; AEC standard—20 nCi/liter.

[d] Milk produced in local dairies but sold by major distributors.

ND, nondetectable, less than sensitivity of analysis.

NS, no sample.

Environmental gamma radiation levels

Monthly measurements of environmental gamma radiation were made with thermoluminescent dosimeters. The January–June 1970 data (table 9) are characteristic of measurements observed at individual stations for the past several years.

Table 9. Environmental gamma radiation Savannah River Plant, January–June 1970

Sampling points	Gamma radiation (mR/24 h)		
	Maximum	Minimum	Average
Plant perimeter:			
A	0.28	0.18	0.22
B	.22	.13	.17
C	.27	.15	.18
D	.26	.14	.18
E	.25	.14	.17
Average			0.18
25-mile radius:			
Aiken Airport	0.21	0.13	0.16
Aiken State Park	.19	.12	.15
Allendale	.23	.13	.18
Barnwell	.38	.17	.21
Bush Field	.27	.18	.21
Langley	.41	.13	.22
Sardis	.20	.14	.18
Waynesboro	.21	.12	.16
Williston	[illegible]	.17	.20
Highway 301	.27	.17	.22
Average			0.19

Summary

The quantity of radioactive waste released by the Savannah River Plant to its environs was, for the most part, too small to be distinguished from natural background radiation or was obscured by fallout from offsite sources. Beta radioactivity in air, which had no relationship to plant operations, was 1.7 times that observed during 1969. Radioactive materials in fish flesh continued to be far below levels considered significant from a health standpoint. The average concentration of any radionuclide in river water at Highway 301 did not exceed [illegible] percent of the AEC radiation protection standard.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1969	May 1970
July–December 1969	December 1970

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Reported Nuclear Detonations, June 1971

(Includes seismic signals presumably from foreign nuclear detonations)

The U.S. Atomic Energy Commission announced that on June 6, 1971, the United States recorded seismic signals, presumably from a Soviet underground explosion. The signals, which originated in the Semipalatinsk nuclear test area, were equivalent to those of an underground nuclear explosion in the low-intermediate yield range (20–200 kilotons TNT equivalent).

Underground nuclear testing at the Nevada Test Site resumed Wednesday, June 16, 1971. A nuclear test in the yield range of less than 20 kilotons was conducted underground by the Atomic Energy Commission at its Nevada Test Site. This test was the first since December 18, 1970.

On June 19, 1971, the United States recorded seismic signals presumably from a Soviet underground nuclear explosion. The signals originated in the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the yield range of 20–200 kilotons.

The U.S. Atomic Energy Commission conducted two underground nuclear tests at its Nevada Test Site on June 23 and 24, 1971. Both were in the low-intermediate yield range (20 to 200 kilotons TNT equivalent).

Seismic signals were recorded by the United States on June 29, 1971, presumably from a Soviet underground nuclear explosion. The signals originated in the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear test in the low-intermediate yield range of 20 to 200 kilotons.

CORRIGENDUM

In the January 1971 issue of *Radiological Health Data and Reports*, a corrigendum occurs in the third paragraph of the article, Reported Nuclear Detonations, December 1970. The date should be corrected in the second line, third paragraph and should read, "the test of December *18*, 1970. Radioactivity..." not December 16 as printed.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U. S. nuclear detonations may be obtained upon request from the Division of Public Information, U. S. Atomic Energy Commission, Washington, D. C. 20545.

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Report of the Venting of the December 18, 1970, Underground Nuclear Detonation

The following report was summarized from the U.S. Atomic Energy Commission's news release of May 14, 1971, as it was deemed of interest to our readers. An investigation was conducted by a committee of technical experts (appointed by the U.S. Atomic Energy Commission) to determine the cause of an accidental release of radioactive material in the test of December 18, 1970.

The first AEC news release of December 18, 1970,[1] stated that a nuclear test of low yield (less than 20 kilotons TNT equivalent) was conducted underground by the Atomic Energy Commission at its Nevada Test Site. Radioactivity at very low levels (less than 1 milliroentgen per hour at populated locations) was recorded on the ground along State Highway 25, north of the test site (figure 1). Monitors and aircraft of the Environmental Protion Agency (formerly the U.S. Public Health Service) monitored the situation continuously. The radioactive air mass moved slowly north and northwest, widening gradually as it moved. Aircraft kept the air mass defined and instruments recorded levels of a few milliroentgens per hour several thousand feet above the ground. None of the readings indicated that there would be a health hazard to persons living downwind.

The committee which investigated the venting was composed of Dr. Wendell Weart of Sandia Laboratories, Albuquerque, N. Mex., Chairman; Dr. Lawrence S. Germain of the Lawrence Radiation Laboratory at Livermore, Calif.; and Dr. Robert R. Brownlee of the Los Alamos Scientific Laboratory, Los Alamos, N. Mex. The findings of this investigative group, which reported to the Manager, Nevada Operations Office, AEC, were endorsed by members of the Manager's Safety Panel of Consultants on Underground Testing.

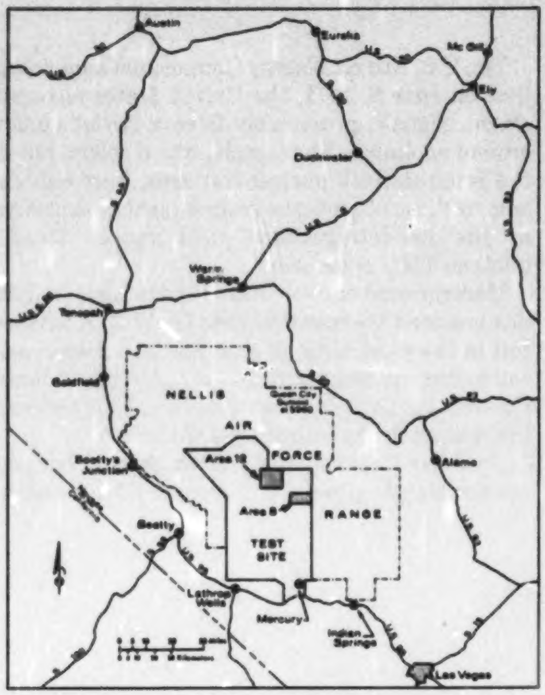

Figure 1. Nevada Test Site and vicinity

The committee determined that the venting of the test—named Baneberry—was caused primarily by the earth around the explosive device being more highly saturated with water than had been anticipated. Baneberry was detonated at a depth of 910 feet in an area of the test site where two other tests (with no problems) had been conducted previously.

The group concluded that the primary cause of venting in the Baneberry test was an unexpected and abnormally high water content (not associated with and well above the normal water table) at an unusually shallow depth in the earth surrounding the detonation point. This increased the coupling of energy into the earth, causing greater than expected close-in ground motions, and creating a crack from the explosion zone to the surface which permitted radioactivity to escape. The nature of the release is what could be expected from an underburied test. Had the same test occurred in the more usual test environment, without the high water content, it would have been contained satisfactorily underground. No preexisting faultline or crack was identified during the study as coinciding with the fissure through which venting occurred.

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[1] Incorrectly reported in the January 1971 issue of *Radiological Health Data and Reports*, p. 80, as December 16, 1970.

Pressures in the cavity created by the explosion lasted longer than normally, principally because of large amounts of water in the surrounding earth. The pressure forced gas through the ground to the surface, where a fissure opened along a line starting at about 60 feet from the surface zero point and extending a total distance of about 315 feet.

As is usual in such tests, the ceiling of the cavity formed underground by the explosion collapsed all the way to the surface in about 16 minutes, forming a saucer-like subsidence. Unlike most previous ventings, the Baneberry collapse did not entirely seal off pathways between the explosion zone and the surface, and radioactive gases continued to be emitted for some hours, in small quantities after the first venting.

Secondary phenomena which may have contributed to the venting include the following. The alluvium above the point of the explosion was of a harder, more consolidated variety than is usually encountered. The region underlying the alluvium is complex in structure, consisting of absorbing clay containing an unusual amount of water.

Nuclear explosive test devices have a range of yields (or amount of explosive force) which is calculated by the design laboratory, in this case, the Lawrence Radiation Laboratory at Livermore, Calif. In the case of the Baneberry test, it has been concluded after careful study that the yield of less than 20 kilotons was essentially as predicted and was not a factor in the venting.

In the case of Baneberry, there was a "line-of-sight pipe" running vertically from near the explosive device to the surface above ground zero. Such pipes, with almost all air evacuated to form a near-vacuum, have been used frequently in association with nuclear tests to obtain scientific data not obtainable in other ways. Various fast closure systems are used in sequence in the pipe to prevent radioactive debris from reaching the surface.

The Baneberry line-of-sight pipe performed as its designers intended, and there is no indication that the pipe had any primary role in the venting.

Baneberry was detonated in a drilled hole with a diameter of 86 inches. It was an uncased hole; that is, the explosive and instrument cannister and the line-of-sight pipe were placed in the hole as drilled. Frequently, a steel casing is used to prevent caving-in of earth and to provide a smooth interior surface for lowering the required packages without hindrance. Many tests involving no venting have been conducted using both cased and uncased holes. There is no evidence that the use of an uncased hole in the Baneberry test contributed in any way to the venting.

Baneberry was sited in Area 8 near the northern boundary of the Yucca Basin of the test site (figure 1). Two previous nuclear tests, one about 2,100 feet north-northeast and the other about 2,000 feet east of the Baneberry site, had presented no problems. However, the drilling history of the Baneberry site indicates a somewhat different geology than in the other two nearby test holes.

During the hole drilling, there was considerable sloughing or caving-in of earth in the lower portion of the hole, and this was overcome by the introduction of large quantities of cement to seal off the loose formations—a standard practice. Considerably more than usual water-absorbing clay was found in the formation, above and below the ultimate explosion point, which it turns out contributed to the problem. The detonation point was above the water table in the area, although all the underground formations in the area contain some water naturally.

Following Baneberry, some of the northern areas of the test site were closed because of residual radioactivity. The Area 12 camp has been reopened for occupancy and normal use, and work is progressing normally in all the areas of the test site. No exposure of onsite personnel exceeded the occupational guides set by the Federal Radiation Council (FRC).

In the offsite area also, all radiation exposures were within the FRC guidelines. The maximum estimated infinite external whole body dose was 0.036 rem to an adult at Clark Station north of the test site. This can be compared with the FRC guide for normal peacetime operations of 0.5 rem per year for an individual member of the public.

After the Western Environmental Research Laboratory (WERL) of the Environmental Protection Agency ended its environmental sampling program following the Baneberry venting, it was learned that in the area north of the Nevada Test Site where radioactivity had been measured, sheepherders were using melted snow as a source of drinking and cooking water.

During the weeks following Baneberry, the sheepherders were in an area from about 30 miles east of Eureka, Nev., on U.S. Highway 50, south to Duckwater, Nev. Based on sampling results in the general area, on information obtained from the eight sheepherders about their location and water consumption, and on snowfall records, WERL estimates the dose to their thyroids from radioactive iodine at about 0.5 rads, plus or minus a factor of 3. The large uncertainty in the estimate results from the fact that there is no detailed information on radioactive contamination levels at the sheepherders' locations; on whether the old snowpack was diluted by new and uncontaminated snow; or about the distribution of the radioactivity at any depth in the snowpack.

For individual members of the general population, the Federal Radiation Council radiation protection guideline for thyroid dose is 1.5 rem per year.

Test resumption was approved under more stringent and detailed technical analysis and review procedures which evolved from the Baneberry investigation. These include a closer examination of the geology of test locations. This will include drilling added exploratory holes when necessary to enhance the understanding of the underground formations involved.

The Atomic Energy Commission has approved the resumption of underground nuclear testing at its Nevada Test Site following completion of an investigation of the cause of an accidental release of radioactive material in a test on December 18, 1970. There were no exposures to the public or workers above Federal Radiation Council guidelines.

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☆ U.S. GOVERNMENT PRINTING OFFICE: – [illegible]

SYNOPSES

Synopses of reports, incorporating list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

EVALUATION OF TELEVISION CONTRIBUTION TO THE ANNUAL GENETICALLY SIGNIFICANT RADIATION DOSE OF THE POPULATION. *X-Radiation Ad Hoc Committee, Electronic Industries Association. Radiological Health Data and Reports, Vol. 12*, July 1971, pp. 363-370.

The X-radiation Ad Hoc Committee of the Electronic Industries Association has used data from a U.S. Public Health Service survey of color television receivers in the Washington, D.C. area to estimate the annual genetically significant x-radiation dose to the U.S. population from television usage. Using these data and various assumptions, the annual genetically significant dose was estimated by the committee to be 0.5 mrem.

KEYWORDS: Color television receivers, genetic dose, U.S. population, Washington, D.C.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 12, Number 8, August 1971

Radiological Health Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

Reports

The Determination of Accuracy and Precision Limits for Tritium in Water

Forrest E. Knowles, Jr. and *Edmond J. Baratta*[1]

This paper describes the procedure for establishing a standard deviation (σ) value for analysis of tritium in water and discusses the results of a technical experiment to test the validity of this value. Since many State, Federal and local laboratories are analyzing this radionuclide on a routine basis, a procedure of quality control to assist in producing comparable and accurate data is necessary. As more nuclear power reactors and nuclear fuel reprocessing plants become operative, tritium will be introduced into the environment in greater quantities. Therefore, other agencies are preparing for tritium analysis capability and will be depending upon this quality control program to assess equipment and sample preparation capabilities.

A standard deviation of 10 percent for single determinations for values equal or to greater than 5 nanocuries per liter was established by assessing data from a tritium cross-check program conducted by the Analytical Quality Control Service of the Office of Radiation Programs, Environmental Protection Agency (EPA). The technical experiment results confirmed this value.

Tritium is a radionuclide that is becoming of increasing concern to the general population. Since the advent of nuclear testing and construction and operation of nuclear power plants and nuclear fuel reprocessing plants, tritium has been introduced into the environment in greater quantities. As a result many Federal, State, local and private agencies have begun analyses of this radionuclide on a routine basis, while others are preparing for this capability. Reactor effluents, municipal water supplies, and rivers near nuclear power reactors and reprocessing plants are among the major environmental media for examination. A procedure of quality control to assist the laboratories in producing accurate and comparable data is necessary. Also this quality control service can help assess the equipment and sample preparation capabilities of the various laboratories.

The Analytical Quality Control Service (AQCS) has attempted to assist in this endeavor by establishing a standard deviation (σ) for tritium analyses and setting up control limits. From these criteria, a laboratory can judge its performance in various experiments and take appropriate corrective action if needed.

This paper describes the procedure for determining a standard deviation for tritium and the results of a technical experiment for validating σ.

Experimental procedure

For the past 2 years, the AQCS has been conducting a tritium cross-check water program with the three EPA laboratories and two other agencies interested in this analysis. The technical experiment consisted of triplicate analyses by each of the participating laboratories on three water samples containing known concentrations (not disclosed to the laboratories) of tritium.

Water samples (A, B, and C) were prepared by adding calibrated solutions of tritium to three 1-liter portions of distilled water. Cobalt-60 was added to sample B as a low energy beta interference. The activity of each sample solution is shown in table 1.

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[1] Analytical Quality Control Service, Environmental Protection Agency, presently located at the Northeastern Radiological Health Laboratory of the Public Health Service, 109 Holton Street, Winchester, Mass. 01890.

Table 1. Radioactivity of the sample solutions

Sample	Tritium[a] (nCi/liter)	Cobalt-60 (nCi/liter)
A	51.8	—
B	168.4	15.0
C	331.4	—

[a] The accuracy of the standards was within ± 2 percent.

The laboratories were sent 50 ml of each sample. They were instructed to perform triplicate analyses using their routine procedure and to forward these results to the AQCS. The AQCS determined the average of each laboratory's analyses and returned a listing of these averages to the laboratories. An example of this report for a particular month is shown in table 2.

Table 2. Tritium analysis—mean values for three determinations

Laboratory	Tritium concentration (nCi/liter)
A	160.7
B	170.0
C	173.7
D	183.0
E	170.0
Known	177.8
Range	22.3

Discussion

After a suitable amount of data was accumulated, a standard deviation value of 10 percent for a single determination was experimentally set by comparing each laboratory's values to the actual concentration in the sample and studying laboratory precision over an extended period of time (1½ years). This σ applied to all tritium values greater than 5 nCi/liter. Using a standard deviation value of 10 percent for a single determination, the control limits were calculated for the mean value of replicate tritium determinations as follows:

$$\pm \text{WL (Warning Level)} = 2\sigma_m$$
$$\pm \text{CL (Control Limit)} = 3\sigma_m$$

$$\sigma_m = \frac{\sigma}{\sqrt{N}} \qquad \ldots(1)$$

where:

σ_m = the effective standard deviation for the mean.

σ = the established standard deviation for a single determination (10 percent of the known), and

N = the number of replicate determinations.

These control limits were then applied to the AQCS cross-check program. A typical report is shown in table 3. Mean values deviating from the known value by an amount less than the warning level were considered acceptable. Those between warning level and control limit were conditionally acceptable. Mean values deviating from the known value by an amount greater than the control limit were considered unacceptable, and an investigation should be made by the laboratories involved.

Table 3. Tritium analysis—control limits for three determinations

Laboratory	Tritium concentration mean value (nCi/liter)
A	47.3
B	46.4
C	47.0
D	47.1
E	54.0
F	58.3
Known	50.4
± WL	5.8
± CL	8.7

In order to test the standard deviation for the mean value, a technical experiment was conducted in cooperation with 16 participants including the EPA laboratories. Results of the experiment were compared to known values by the use of control charts as shown in figure 1.

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MEAN CHART Sample A- $^{3}H = 51.8$ nCi/liter, $N = 3$

$\bar{x} + \frac{3\sigma}{\sqrt{N}}$	60.8	Upper Control Limit (UCL)
$\bar{x} + \frac{2\sigma}{\sqrt{N}}$	57.8	Upper Warning Level (UWL)
$\bar{x}$	51.8	Standard Mean (Expected Value)
$\bar{x} - \frac{2\sigma}{\sqrt{N}}$	45.8	Lower Warning Level (LWL)
$\bar{x} - \frac{3\sigma}{\sqrt{N}}$	42.8	Lower Control Limit (LCL)

RANGE CHART Sample A- $^{3}H = 51.8$ nCi/liter, $N = 3$

$D_4 \bar{R}$	22.6	Upper Control Limit (UCL)
$\bar{R} + \frac{2}{3}(D_4 \bar{R} - \bar{R})$	18.0	Upper Warning Level (UWL)
$\bar{R} = d_2\sigma$	8.8	Mean Range (Expected Range)
$D_3 \bar{R}$	0	Lower Limit (LL)

Figure 1. Examples of "Mean and Range Control Charts"-
d_2, D_4, and D_3 are values taken from standard statistical tables prepared for the construction of range control charts and based on the value of N

The mean values were used for the data analyses because the range values did not vary significantly between laboratories and were well within the warning levels. All laboratory mean values were included. The data are presented in figures 2 to 4.

Analysis of data for precision was accomplished by comparing the standard deviation of each laboratory's individual results for each sample with the 10 percent standard deviation values established by the AQCS as shown in table 4.

Table 4. Data analysis of technical experiment-precision

Sample	Known σ and (percent)	Laboratory σ[a] and (percent)
A	5.18 (10)	7.7 (14)
B	14.6 (10)	25.1 (16)
C	33.1 (10)	56.0 (16)

[a]
$$\sigma = \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{N - 1}}$$
where: N = number of laboratories,
$\bar{x}$ = average of sample activity of all analyses.
x_i = individual laboratory results.

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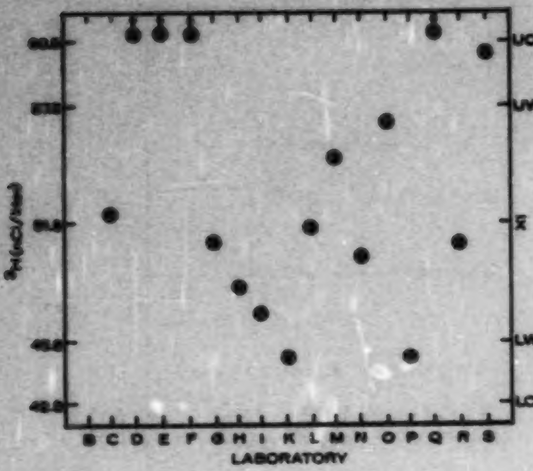

Figure 2. "Mean Chart," sample A, 51.8 nCi/liter, N = 3

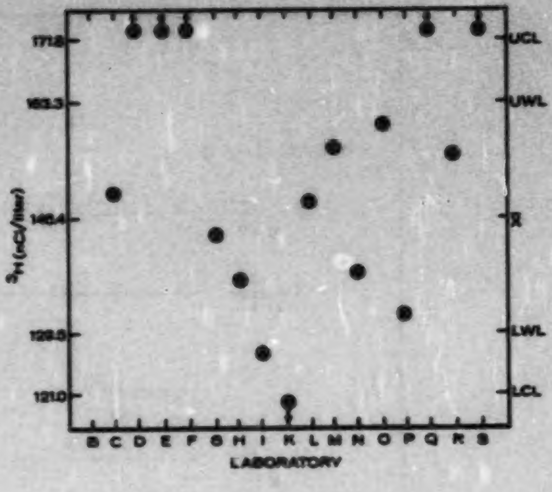

Figure 3. "Mean Chart," sample B, 146.4 nCi/liter, N = 3

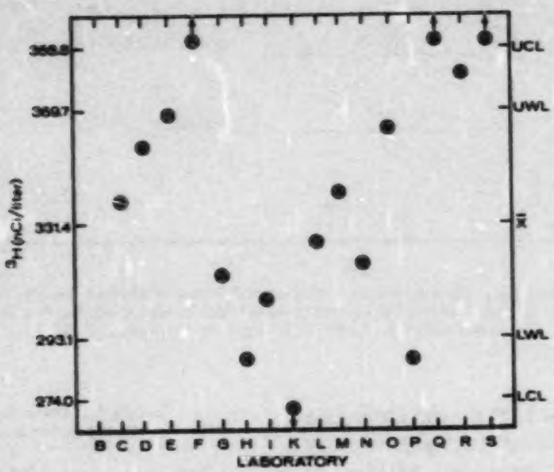

Figure 4. "Mean Chart," sample C, 331.4 nCi/liter, N = 3

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To determine the accuracy of the tritium procedures, the difference between the mean values and the known values was compared to the established standard deviation for a single determination and for three determinations. The results are shown in tables 5 and 6.

Table 5. Data analysis of technical experiment

Sample	Amount present (nCi/liter)	Average of means (nCi/liter)
A	51.8	54.3
B	146.4	154.7
C	331.4	342.5

Table 6. Data analysis of technical experiment—accuracy

Sample	Difference (nCi/liter)	Percent[a]	σ[b] (nCi/liter)	σ_m[c] (nCi/liter)
A	2.5	4.8	5.18	3.0
B	8.3	5.7	14.6	8.4
C	11.1	3.3	33.1	19.1

[a] Percent = $\frac{\text{difference}}{\text{average amount present}}$

[b] σ = standard deviation for tritium, single determination (10 percent)

[c] σ_m = standard deviation for tritium, three determinations $\left(\frac{\sigma}{\sqrt{N}}\right)$

Conclusions

The calculated σ for the three samples is larger than the one established for tritium in the precision analysis (table 4) because a few participants had values differing from the known greatly in excess of the control limits. The data were recalculated excluding three laboratories, and the value came close to 10 percent. (A = 10.5, B = 11.2, C = 11.4). The relative σ does not seem to be dependent upon sample activity.

The analysis of accuracy (table 6) shows that the percent difference between the average amount present and average amount found is comparable to the established standard deviation. In some cases, these values are much better than expected.

From the data shown in the tables and figures, it appears that the established 10 percent standard deviation is valid. Values lower than 50 nCi/liter (25–30 nCi/liter) have been used in the cross-check program with similar results. Levels nearer 1–5 nCi/liter will be investigated in future studies, as some laboratories in the program routinely count samples at these lower levels. Due to the greater influence of background at 5 nCi/liter or less, the 10 percent standard deviation will have to be revised upward.

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, April 1971

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk,

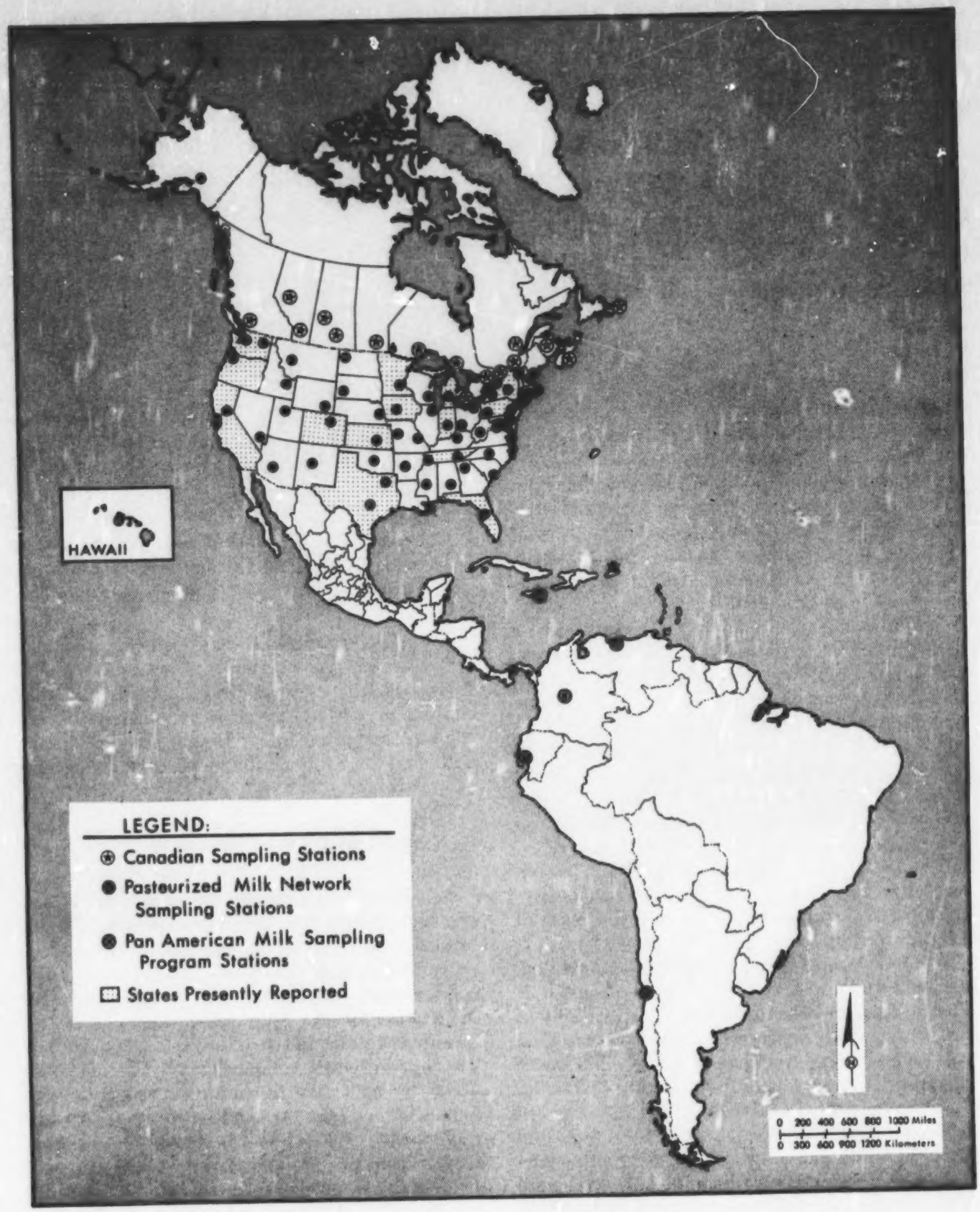
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
● Pan American Milk Sampling Program Stations
▨ States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during May–July 1970, with 28 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 (*5*). Of the 18 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 13 participated in the experiment.

The accuracy results of this experiment are shown in table 1. In general, considerable improvement is needed, especially in the accuracy measurements. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, io-

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration		Number of laboratories in each category			
		Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Strontium 89:	High (258 pCi/liter)	7 (44%)	1 (6%)	8 (50%)	16
	Low (15 pCi/liter)	11 (69%)	3 (19%)	2 (12%)	16
Strontium-90:	Intermediate (79.4 pCi/liter)	13 (57%)	4 (17%)	6 (26%)	23
	Low (32.0 pCi/liter)	5 (25%)	4 (20%)	11 (55%)	20
Iodine-131:	High (507 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
	Low (49 pCi/liter)	16 (64%)	3 (12%)	6 (24%)	25
Cesium-137:	High (259 pCi/liter)	20 (74%)	3 (11%)	4 (15%)	27
	Low (53 pCi/liter)	17 (65%)	5 (19%)	4 (15%)	26
Barium-140:	High (302 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
	Low (33 pCi/liter)	23 (92%)	0	2 (8%)	25

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

dine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*7*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environment conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90, iodine-131, and cesium-137 for April 1971 and the 12-month period, May 1970 to

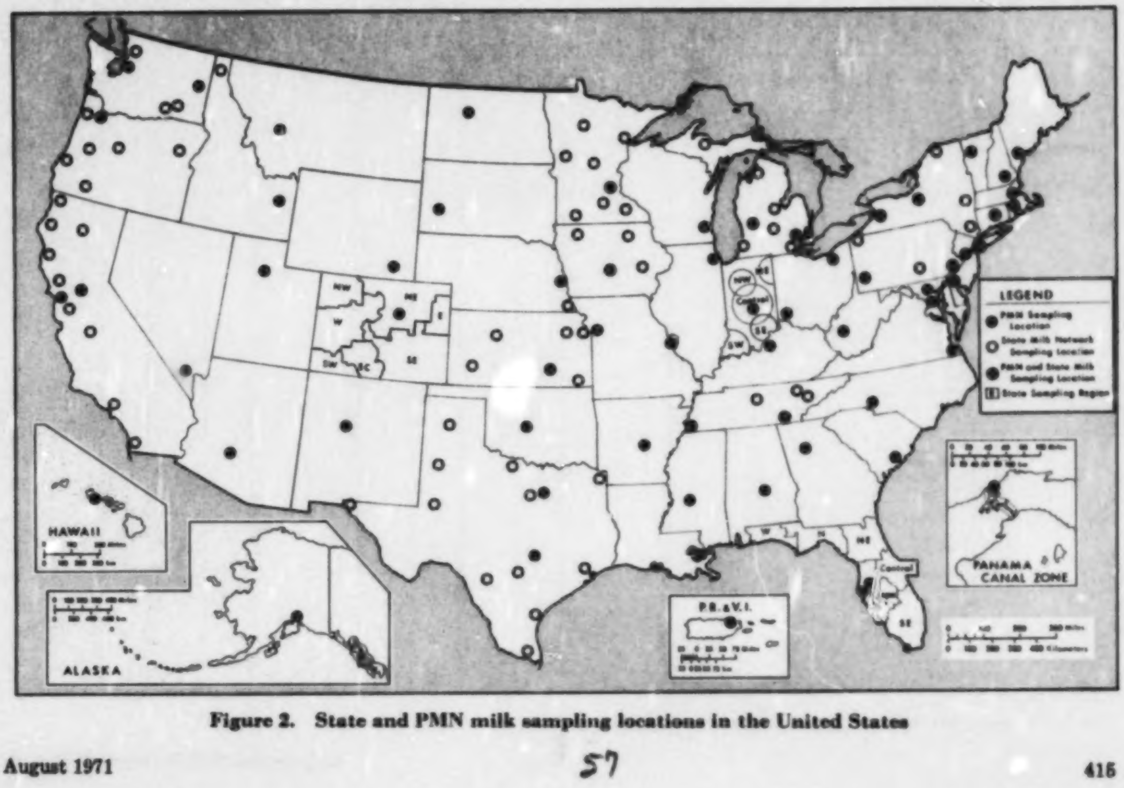

Figure 2. State and PMN milk sampling locations in the United States

Table 2. Concentrations of radionuclides in milk for April 1971 and 12-month period, May 1970 through April 1971

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	8	6	0	0	12	9
Alaska:	Palmer[c]	P	3	5	0	0	20	13
Ariz:	Phoenix[c]	P	0	1	0	0	0	0
Ark:	Little Rock[c]	P	14	13	0	0	30	12
Calif:	Sacramento[c]	P	2	1	0	0	0	0
	San Francisco[c]	P	5	2	0	0	0	0
	Del Norte	P	24	17	0	0	21	11
	Fresno	P	0	2	0	0	0	1
	Humboldt	P	3	4	0	0	NA	4
	Los Angeles	P	2	2	0	0	0	1
	Mendocino	P	17	4	0	0	0	1
	Sacramento	P	3	3	0	0	0	1
	San Diego	P	2	2	0	0	0	1
	Santa Clara	P	0	2	0	0	0	0
	Shasta	P	3	3	0	0	0	2
	Sonoma	P	5	3	0	0	9	2
Colo:	Denver[c]	P	5	5	0	0	14	3
	West	R	(d)		[e]0	[e]0	[e]0	[e]0
	Northeast	R	(d)		NS	[e]0	NS	[e]0
	East	R	(d)		NS	[e]0	NS	[e]0
	Southeast	R	(d)		[e]0	[e]0	[e]0	[e]0
	South Central	R	(d)		NS	NS	NS	NS
	Southwest	R	(d)		NS	[e]0	NS	[e]4
	Northwest	R	(d)		[e]0	[e]5	[e]0	[e]0
Conn:	Hartford[c]	P	6	8	0	0	16	13
	Central	P	7	7	0	0	10	15
Del:	Wilmington[c]	P	8	9	0	0	11	8
D.C:	Washington[c]	P	9	7	0	0	18	10
Fla:	Tampa[c]	P	4	5	0	0	31	50
	West	R	6	9	0	0	20	18
	North	R	6	10	0	0	22	26
	Northeast	R	6	7	0	0	19	34
	Central	R	4	6	0	0	23	48
	Tampa Bay area	R	6	6	0	0	45	46
	Southeast	R	5	7	0	1	27	79
Ga:	Atlanta[c]	P	11	12	0	0	17	14
Hawaii:	Honolulu[c]	P	0	2	0	0	0	0
Idaho:	Idaho Falls[c]	P	5	5	0	0	0	8
Ill:	Chicago[c]	P	6	7	0	0	12	12
Ind:	Indianapolis[c]	P	8	8	0	0	14	8
	Northeast	P	10	10	0	0	20	14
	Southeast	P	9	11	0	0	20	12
	Central	P	8	9	0	5	15	10
	Southwest	P	12	13	0	0	5	9
	Northwest	P	10	11	0	0	15	12
Iowa:	Des Moines[c]	P	NA	6	0	0	0	3
	Iowa City	P	10	8	0	0	12	13
	Des Moines	P	6	8	0	0	15	12
	Spencer	P	NS	NS	NS	NS	NS	NS
	Fredericksburg	P	NS	NS	NS	NS	NS	NS
Kans:	Wichita[c]	P	7	7	0	0	0	3
	Coffeyville	P	7	9	14	3	21	6
	Dodge City	R	5	5	0	0	0	2
	Falls City	P	NS	12	NS	3	NS	8
	Hays	P	7	12	0	2	11	4
	Kansas City	P	7	8	22	5	26	12
	Topeka	P	7	10	0	0	15	9
	Wichita	P	9	12	0	0	0	4
Ky:	Louisville[c]	P	9	10	0	0	11	4
La:	New Orleans[c]	P	NS	14	NS	0	NS	19
Maine:	Portland[c]	P	9	10	0	0	22	22
Md:	Baltimore[c]	P	7	8	0	0	0	7
Mass:	Boston[c]	P	8	10	0	0	15	22
Mich:	Detroit[c]	P	8	8	0	0	16	11
	Grand Rapids[c]	P	9	9	0	0	18	14
	Bay City	P	NS	7	NS	[e]0	NS	12
	Charlevoix	P	11	12	[e]0 (2)	[e]1	17 (2)	15
	Detroit	P	6	8	[e]0	[e]0	17	8
	Grand Rapids	P	10	9	[e]0	[e]0	20	9
	Lansing	P	NA	9	[e]0 (2)	[e]0	11 (2)	14
	Marquette	P	7	12	[e]0 (2)	[e]0	27 (2)	23
	Monroe	P	9	6	[e]0 (2)	[e]0	8 (2)	4
	South Haven	P	5	8	[e]0 (3)	[e]0	16 (3)	6
Minn:	Minneapolis[c]	P	7	10	0	0	19	13
	Bemidji	P	4	7	0	0	20	21
	Mankato	P	7	5	0	0	13	11
	Rochester	P	7	8	0	0	16	16
	Duluth	P	17	15	0	0	28	28
	Worthington	P	6	4	0	0	0	0
	Minneapolis	P	11	11	0	0	14	14

See footnotes at end of table.

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Table 2. Concentration of radionuclides in milk for April 1971 and 12-month period, May 1970 through April 1971—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
Minn:	Fergus Falls	P	7	6	0	0	13	15
	Little Falls	P	17	13	0	0	25	25
Miss:	Jackson[c]	P	14	12	0	0	13	10
Mo:	Kansas City[c]	P	6	8	0	0	14	4
	St. Louis[c]	P	8	9	0	0	0	4
Mont:	Helena[c]	P	5	5	0	0	0	9
Nebr:	Omaha[c]	P	8	5	0	0	0	1
Nev:	Las Vegas[c]	P	0	2	0	0	0	0
N.H:	Manchester[c]	P	7	9	0	0	21	22
N.J:	Trenton[c]	P	10	9	0	0	14	12
N. Mex:	Albuquerque[c]	P	0	3	0	0	0	0
N.Y:	Buffalo[c]	P	8	8	0	0	22	13
	New York City[c]	P	8	10	0	0	14	18
	Syracuse[c]	P	6	7	0	0	20	11
	Albany	P	8	9	0 (4)	0	21 (4)	[e]0
	Massena	P	7	8	0 (2)	0	21 (2)	25
	Newburg	P	4	8	0 (4)	0	[e]0 (4)	[e]0
	New York City	P	11	10	0	0	22	[e]0
	Syracuse	P	[e]0	4	0 (2)	0	[e]0 (2)	[e]0
N.C:	Charlotte[c]	P	10	11	0	0	17	12
N. Dak:	Minot[c]	P	8	9	0	0	11	10
Ohio:	Cincinnati[c]	P	7	8	0	0	0	3
	Cleveland[c]	P	7	8	0	0	12	12
Okla:	Oklahoma City[c]	P	6	6	0	0	0	6
Oreg:	Portland[c]	P	6	5	0	0	15	4
	Baker	P	NA	4	[e]0	[e]0	[e]0	9
	Coos Bay	P	NA	7	[e]0	[e]0	24	13
	Eugene	P	NA	3	[e]0	[e]0	[e]0	1
	Medford	P	NA	3	[e]0	[e]0	[e]0	9
	Portland composite	P	NA	6	[e]0	[e]0	[e]0	6
	Portland local	P	NA	5	[e]0	[e]0	9	8
	Redmond	P	NA	3	[e]0	[e]0	25	2
	Tillamook	P	NA	7	[e]0	[e]0	[e]0	15
Pa:	Philadelphia[c]	P	7	9	0	0	12	8
	Pittsburgh[c]	P	11	11	0	0	11	16
	Dauphin	P	10	8	0	1	14	13
	Erie	P	NS	11	NS	0	NS	26
	Philadelphia	P	8	9	0	0	11	15
	Pittsburgh	P	14	12	0	1	19	21
R.I:	Providence[c]	P	7	9	0	0	19	19
S.C:	Charleston[c]	P	9	9	0	1	0	15
S. Dak:	Rapid City[c]	P	NS	7	NS	0	NS	5
Tenn:	Chattanooga[c]	P	7	9	0	0	13	9
	Memphis[c]	P	7	8	0	0	14	8
	Chattanooga	P	NA	9	0	0	23	16
	Clinton	P	NA	10	0	0	21	17
	Fayetteville	P	NA	11	0	0	24	15
	Knoxville	P	NA	7	0	0	20	14
	Nashville	P	NA	6	0	0	18	11
Tex:	Austin[c]	P	3	2	0	0	0	2
	Dallas[c]	P	8	7	0	0	0	5
	Amarillo	R	NS	4	0	0	0	5
	Corpus Christi	R	NS	3	0	0	0	0
	El Paso	R	NS	3	0	0	0	2
	Fort Worth	R	NS	4	0	0	0	0
	Harlingen	R	NS	2	0	0	0	0
	Houston	R	9	6	0	0	15	18
	Lubbock	R	NS	3	0	0	0	0
	Midland	R	2	2	0	0	0	0
	San Antonio	R	NS	3	0	0	0	0
	Texarkana	R	NS	NS	NS	NS	NS	NS
	Tyler	R	18	14	0	0	10	15
	Uvalde	R	NS	2	0	0	0	0
	Wichita Falls	R	NS	8	0	0	0	0
Utah:	Salt Lake City[c]	P	4	4	0	0	21	13
Vt:	Burlington[c]	P	6	7	0	0	0	14
Va:	Norfolk[c]	P	7	9	0	0	0	8
Wash:	Seattle[c]	P	4	5	0	0	0	3
	Spokane[c]	P	5	5	0	0	0	1
	Benton County	R	NS	1	NS	0	NS	2
	Franklin County	R	3	3	0	0	10	3
	Sandpoint, Idaho	R	9	11	0	0	17	22
	Skagit County	R	8	7	0	0	13	11
W. Va:	Charleston[c]	P	8	8	0	0	14	7
Wisc:	Milwaukee[c]	P	6	6	0	0	14	13
Wyo:	Laramie[c]	P	7	5	0	0	0	1
CANADA:								
Alberta:	Calgary	P	(d)		(d)		18	18

See footnotes at end of table.

Table 2. Concentration of radionuclides in milk for April 1971 and 12-month period, May 1970 through April 1971—Continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)					
		Strontium-90		Iodine-131		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—Continued							
Edmonton	P	(d)		(d)		24	21
British Columbia:							
Vancouver	P	(d)		(d)		19	24
Manitoba: Winnipeg	P	(d)		(d)		20	25
New Brunswick:							
Fredericton	P	(d)		(d)		24	24
Newfoundland:							
St. John's	P	(d)		(d)		17	32
Nova Scotia: Halifax	P	(d)		(d)		21	21
Ontario: Ottawa	P	(d)		(d)		14	16
Sault Ste. Marie	P	(d)		(d)		27	33
Ontario: Thunder Bay	P	(d)		(d)		17	32
Toronto	P	(d)		(d)		11	11
Windsor	P	(d)		(d)		11	11
Quebec: Montreal	P	(d)		(d)		19	19
Quebec	P	(d)		(d)		30	29
Saskatchewan:							
Regina	P	(d)		(d)		17	14
Saskatoon	P	(d)		(d)		17	18
CENTRAL AND SOUTH AMERICA:							
Colombia: Bogota	P	2	1	0	0	0	0
Chile: Santiago	P	0	0	0	0	0	0
Ecuador: Guayaquil	P	0	0	0	0	0	0
Jamaica: Kingston	P	NS	5	NS	0	NS	81
Venezuela: Caracas	P	0	1	0	0	0	0
Canal Zone: Cristobal[c]	P	NS	2	NS	0	NS	10
Puerto Rico: San Juan[c]	P	4	4	0	0	21	9
PMN network average[f]			7	0	0	10	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclides concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

April 1971. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for April 1971 were below the respective practical reporting levels. The following station averages reflect samples in which strontium-89 was detected: Calif., San Francisco, 13 pCi/liter, Del Norte, 26 pCi/liter, Humboldt, 7 pCi/liter, Mendocino, 48 pCi/liter, Sonoma, 20 pCi/liter; Kans., Coffeyville, 11 pCi/liter, Dodge City, 9 pCi/liter, Kansas City, 6 pCi/liter, Topeka, 9 pCi/liter. Barium-140 was detected at Coffeyville, and Kansas City, Kans., 11 pCi/liter, respectively.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower guide levels established by the Federal Radiation Council, levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 24 pCi/liter in the United States for April 1971, and the highest 12-month average was 17 pCi/liter (Del Norte, Calif.) representing 8.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged

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from 0 to 45 pCi/liter in the United States for the month of April 1971, and the highest 12-month average was 79 pCi/liter (Southeast Florida), representing 2.2 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica. Iodine-131 results for individual samples were all below the practical reporting level, with the exception of Kansas, Kansas City (State), 14 pCi/liter.

Acknowledgment

Appreciation is expressed to the personnel of the following agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. *Programs reported in Radiological Health Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January–June 1970	November 1970
Carbon-14 in Total Diet and Milk	July–December 1970	May 1971
Connecticut Standard Diet	July–December 1969	December 1970
Institutional Diet Samples	October–December 1970 and Annual Summary 1970	May 1971
Strontium-90 in Tri-City Diets	January–December 1969	June 1970

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (2–4), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	July–December 1968	August 1970
Interstate Carrier Drinking Water	1970	July 1971
Kansas	January–December 1969	September 1970
Minnesota	July–December 1969	May 1971
North Carolina	January–December 1967	May 1969
New York	January–June 1969	June 1970
Radiostrontium in Tap Water, *HASL*	January–December 1969	July 1970
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	January–March 1971	July 1971
Washington	July 1968–June 1969	February 1971

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
Fallout in the United States and other Areas, *HASL*	July–December 1968 and January–December 1969	January 1971
Plutonium in Airborne Particulates and Precipitation	July–December 1970	June 1971
Surface Air Sampling Program, 80th Meridian Network, *HASL*	January–December 1968	April 1971

1. Radiation Alert Network
April 1971

Office of Air Programs
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of these stations are operated by State Health Department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A complication of the daily field estimates is available upon request from the Data Aquisition and Analysis Branch, Division of Air Quality and Emission Data, EPA, Cincinnati, Ohio. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during April 1971. All field estimates reported were within normal limits for the reporting station.

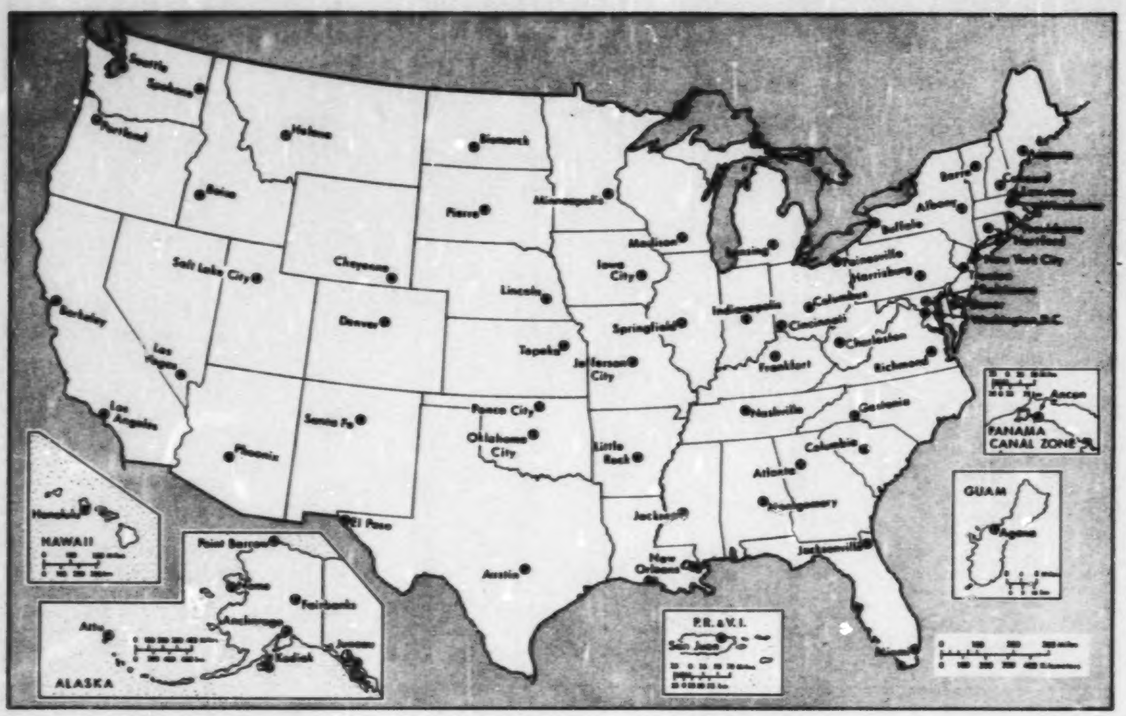
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Salt Lake City
Cheyenne
Iowa City
Lincoln
Berkeley
Denver
Springfield
Indianapolis
Columbus
Cincinnati
Topeka
Jefferson City
Frankfort
Charleston
Richmond
Las Vegas
Los Angeles
Ponca City
Oklahoma City
Santa Fe
Phoenix
Little Rock
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jackson
New Orleans
El Paso
Austin
Jacksonville
Miami
Buffalo
Albany
Barre
Painesville
Harrisburg
New York City
Hartford
Washington, D.C.
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Juneau
Kodiak
Attu
ALASKA
P.R. & V.I.
San Juan
GUAM
Agana
Ancon
PANAMA CANAL ZONE

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, April 1971

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Precipitation				
						Number of samples	Total depth (mm)	Field estimation of deposition		
			Maximum	Minimum	Average[a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	22	6	0	2	4	181	4	181	75
Alaska:	Adak	1	0	0	0	0				
	Anchorage	30	0	0	0	0				
	Attu Island	0				0				
	Fairbanks	13	3	1	2	7	105	6	85	0
	Juneau	4	0	0	0	0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	13	5	1	3	0				
Ark:	Little Rock	6	2	1	1	0				
Calif:	Berkeley	22	1	0	0	3	22	3	22	0
	Los Angeles	22	4	0	1	0				
C.Z:	Ancon	15	0	0	0	0				
Colo:	Denver	22	5	1	2	6	53	(b)		
Conn:	Hartford	21	1	0	0	7	61	7	61	2
Del:	Dover	21	2	0	1	0				
D.C:	Washington	25	2	0	1	0				
Fla:	Jacksonville	22	2	1	1	5	64	3	24	1
	Miami	21	1	0	1	1	[illegible]	1	7	0
Ga:	Atlanta	20	2	1	1	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	25	1	0	0	4	69	(b)		
Idaho:	Boise	22	4	1	2	3	11	3	11	1
Ill:	Springfield	4	2	1	1	0				
Ind:	Indianapolis	21	2	0	1	0				
Iowa:	Iowa City	18	6	1	2	2	18	2	18	4
Kans:	Topeka	21	4	1	2	6	26	6	26	2
Ky:	Frankfort	0				0				
La:	New Orleans	17	1	0	1	3	23	(b)		
Maine:	Augusta	21	1	0	0	6	53	5	40	0
Md:	Baltimore	21	2	0	1	4	28	4	28	0
Mass:	Lawrence	21	1	0	0	6	55	6	55	1
	Winchester	22	1	0	1	6	77	6	77	0
Mich:	Lansing	21	1	0	1	5	30	5	30	7
Minn:	Minneapolis	22	3	0	1	5	38	5	38	12
Miss:	Jackson	18	2	0	1	5	242	5	242	4
Mo:	Jefferson City	21	4	1	2	4	19	4	19	4
Mont:	Helena	20	3	1	1	1	7	1	7	0
Nebr:	Lincoln	21	10	1	4	1	8	1	8	0
Nev:	Las Vegas	21	3	1	2	0				
N.H:	Concord	0				0				
N.J:	Trenton	22	2	0	1	3	66	3	66	5
N. Mex:	Santa Fe	14	2	1	1	3	34	3	34	4
N.Y:	Albany	20	1	0	0	0				
	Buffalo	19	2	0	1	0				
	New York City	0				0				
N.C:	Gastonia	16	11	0	3	3	41	(b)		
N. Dak:	Bismarck	21	4	0	2	5	38	5	38	4
Ohio:	Cincinnati	10	4	0	2	0				
	Columbus	5	3	1	2	0				
	Painesville	22	3	0	1	8	37	8	37	4
Okla:	Oklahoma City	0				0				
	Ponca City	21	8	1	2	6	92	6	92	1
Oreg:	Portland	22	1	0	0	11	90	11	90	7
Pa:	Harrisburg	18	3	0	1	0				
P.R:	San Juan	0				0				
R.I:	Providence	20	2	0	1	0				
S.C:	Columbia	21	2	0	1	4	110	4	110	1
S. Dak:	Pierre	20	6	1	2	0				
Tenn:	Nashville	14	3	0	1	6	78	6	78	8
Tex:	Austin	0				0				
	El Paso	0				0				
Utah:	Salt Lake City	30	4	0	1	8	129	8	129	51
Vt:	Barre	0				0				
Va:	Richmond	22	2	0	1	2	20	2	20	2
Wash:	Seattle	9	0	0	0	3	46	(b)		
	Spokane	18	2	0	1	0				
W. Va:	Charleston	20	5	1	2	5	30	5	30	8
Wisc:	Madison	18	3	0	1	8	85	8	85	24
Wyo:	Cheyenne	21	6	0	2	6	69	6	69	24
Network summary		1,080	11	0	1	175	68	5	58	8

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.

[b] This station is part of the plutonium in precipitation network. No gross beta measurements are done.

2. Canadian Air and Precipitation Monitoring Program,[1] April 1971

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for April 1971 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, April 1971

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	4	0.2	0.1	0.2	33	0.59
Coral Harbour	4	.3	.1	.2	154	1.95
Edmonton	4	.4	.4	.4	413	2.63
Ft. Churchill	4	.2	.1	.1	80	1.53
Fredericton	4	.3	.1	.2	74	6.21
Goose Bay	4	.2	.1	.2	40	2.81
Halifax	27	.2	.1	.1	117	17.39
Inuvik	4	.2	.1	.1	93	.85
Montreal	4	.2	.1	.2	207	9.39
Moosonee	4	.3	.2	.3	58	2.10
Ottawa	4	.3	.2	.3	159	7.60
Quebec	4	.2	.0	.1	209	7.06
Regina	4	.4	.2	.3	291	6.41
Resolute	4	.2	.2	.2	109	1.24
St. John's, Nfld	4	.2	.1	.1	143	27.54
Saskatoon	4	.2	.2	.2	491	10.20
Sault Ste. Marie	4	.4	.1	.3	167	5.08
Thunder Bay	4	.2	.1	.2	252	6.27
Toronto	4	.3	.1	.2	291	8.13
Vancouver	4	.2	.1	.2	104	5.27
Whitehorse	4	.4	.1	.2	125	.73
Windsor	4	.2	.1	.2	82	2.45
Winnipeg	4	.3	.1	.2	314	18.84
Yellowknife	4	.1	.0	.1	NS	NS
Network summary	119	0.4	0.0	0.2	174	6.62

NS, no sample.

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

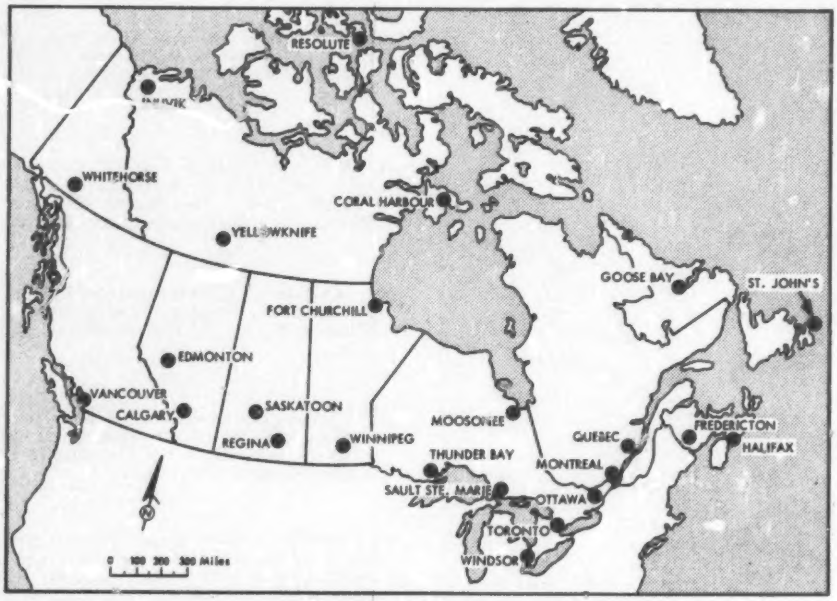
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
0 100 200 300 Miles

Figure 2. Canadian air and precipitation sampling stations

3. Pan American Air Sampling Program April 1971

Pan American Health Organization and *Environmental Protection Agency*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The April 1971 air monitoring results from the participating countries are given in table 3.

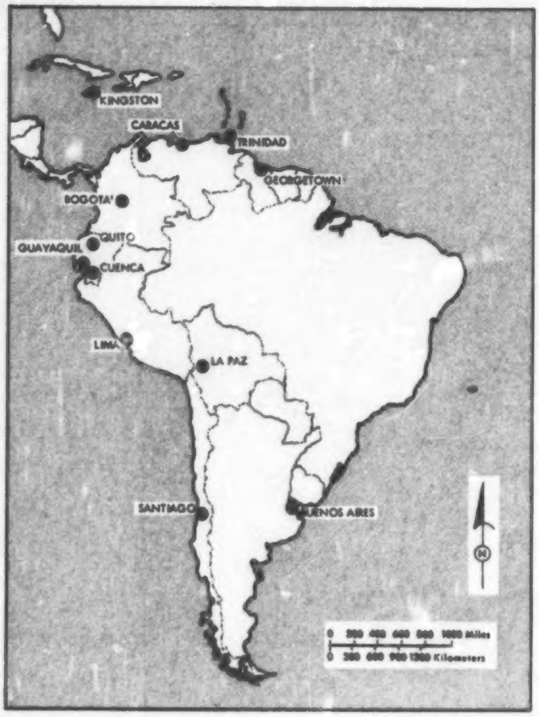

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, April 1971

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	19	0.17	0.01	0.04
Chile:	Santiago	30	.40	.03	.19
Colombia:	Bogota	19	.18	.01	.05
Ecuador:	Cuenca	6			
	Guayaquil	11	.21	.07	.10
	Quito	0			
Guyana:	Georgetown	8	.90	.12	.34
Jamaica:	Kingston	0			
Peru:	Lima	17	.13	.03	.07
Venezuela:	Caracas	7	.92	.19	.43
West Indies:	Trinidad	16	.94	.20	.51
Pan American summary		127	.94	.01	.19

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

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(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Oak Ridge Area and Savannah River Plant.

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[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Oak Ridge Area[2]
July-December 1969

Union Carbide Nuclear Company
Oak Ridge, Tenn.

Oak Ridge area is a complex made up primarily of the Y-12 Plant, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in the Oak Ridge area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ability to fix radioactive materials by an ion exchange mechanism. Liquid wastes which contain long-lived fission products are confined in storage tanks or are concentrated by evaporation and disposed of in deep wells. Low-level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

Air monitoring

Atmospheric contamination by radioactive materials occurring in the general environment of East Tennessee is monitored by two systems of monitoring stations. One system consists of nine stations which encircle the plant areas (figure 1) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of eight stations encircling the Oak Ridge area at distances of from 12 to 75 miles (figure 2). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur.

Sampling for radioactive particulates is carried out by passing air continuously through a filter paper. Average radioactivity concentrations are presented in tables 1 and 2. Airborne radioactive iodine is monitored in the immediate environment

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[2] Summarized from Environmental Levels of Radioactivity for the Oak Ridge area, (Report Period July–December 1969). Health Physics and Safety Section, Health Physics Division, Oak Ridge National Laboratory.

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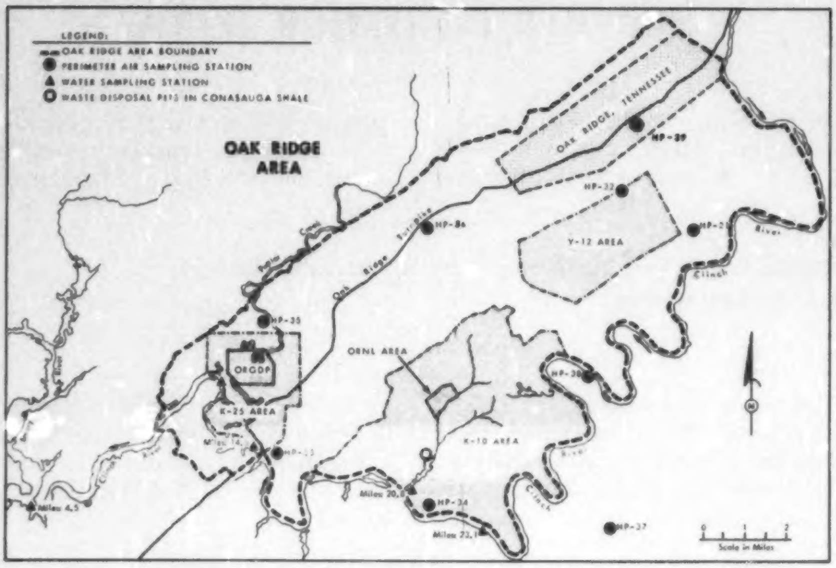
LEGEND:
OAK RIDGE AREA BOUNDARY
PERIMETER AIR SAMPLING STATION
WATER SAMPLING STATION
WASTE DISPOSAL PITS IN CONASAUGA SHALE
OAK RIDGE AREA
OAK RIDGE, TENNESSEE
HP-39
HP-32
Y-12 AREA
HP-38
HP-31
Oak Ridge Turnpike
Poplar Creek
River
Clinch
HP-35
ORGDP
K-25 AREA
ORNL AREA
HP-36
K-10 AREA
Miles 14.
HP-33
Clinch River
Miles 4.5
Miles 20.8
HP-34
Miles 23.1
HP-37
N
0 1 2
Scale in Miles

Figure 1. Oak Ridge area, environmental sampling locations

of the plant areas by passing air through a cartridge containing activated charcoal.

During the July–December 1969 surveillance period, 233 samples were collected from perimeter monitoring stations and analyzed for iodine-131. Of these, the maximum concentration detected was 0.15 pCi/m^3, the minimum was less than 0.01 pCi/m^3, and the average was 0.01 pCi/m^3. The radiation protection standard specified in the AEC Manual for iodine-131 in the ambient atmosphere in uncontrolled areas is 100 pCi/m^3.

Milk monitoring

Raw milk is monitored for iodine-131 and strontium-90 by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of ORNL. Samples are collected weekly at each of eight stations located on the fringe of the Oak Ridge area. Four stations, located more remotely with respect to the Oak Ridge operations, are sampled at a rate of one station each week. The purpose of the milk

Table 1. Long-lived gross beta radioactivity of particulates in air, Oak Ridge Area, July–December 1969

Perimeter stations						Remote stations					
Station number (figure 1)	Number of samples	Concentration (pCi/m^3)			Percent of AEC standard[a]	Station number (figure 2)	Number of samples	Concentration (pCi/m^3)			Percent of AEC standard[a]
		Maximum	Minimum	Average				Maximum	Minimum	Average	
HP-31	25	0.43	0.032	0.16	0.16	HP-51	26	0.42	0.047	0.16	0.16
HP-32	26	.53	.025	.19	.19	HP-52	25	.50	.035	.17	.17
HP-33	26	.35	<.001	.12	.12	HP-53	26	.49	.008	.16	.16
HP-34	26	.43	.038	.14	.14	HP-54	25	.42	.035	.15	.15
HP-35	26	.44	.042	.16	.16	HP-55	25	.32	.013	.11	.11
HP-36	[b]119	.43	.019	.18	.18	HP-56	26	.55	.021	.17	.17
HP-37	26	.39	.007	.16	.16	HP-57	26	.46	.038	.16	.16
HP-38	26	.43	.035	.16	.16	HP-58	23	.49	.030	.19	.19
HP-39	26	.57	.040	.19	.19						
Summary	326	0.57	<0.001	0.16	0.16	Summary	202	0.55	0.008	0.16	0.16

[a] The applicable AEC Radiation Protection Standard is 100 pCi/m^3.
[b] Sample frequency—5 days per week.

Table 2. Long-lived gross alpha radioactivity of particulates in air, Oak Ridge Area, July–December 1969

Perimeter stations						Remote stations					
Station number (figure 1)	Number of samples	Concentration (pCi/m³)			Percent of AEC standard[a]	Station number (figure 2)	Number of samples	Concentration (pCi/m³)			Percent of AEC standard[a]
		Maximum	Minimum	Average				Maximum	Minimum	Average	
HP-31	25	0.006	<0.001	0.002	0.10	HP-51	26	0.003	<0.001	0.001	0.05
HP-32	25	.008	< .001	.002	.10	HP-52	25	.005	< .001	.002	.10
HP-33	26	.005	< .001	.002	.10	HP-53	26	.004	< .001	.001	.05
HP-34	26	.003	< .001	.001	.05	HP-54	25	.004	< .001	.001	.05
HP-35	26	.008	< .001	.002	.10	HP-55	25	.003	< .001	.001	.05
HP-36	[b]119	.025	< .001	.005	.25	HP-56	26	.004	< .001	.001	.05
HP-37	26	.005	< .001	.002	.10	HP-57	26	.004	< .001	.001	.05
HP-38	26	.003	< .001	.001	.05	HP-58	24	.006	< .001	.002	.10
HP-39	26	.008	< .001	.002	.10						
Summary	326	0.025	<0.001	0.002	0.10	Summary	203	0.006	<0.001	0.001	0.05

[a] The applicable AEC Radiation Protection Standard for natural uranium in air is 2 pCi/m³.
[b] Sample frequency—5 days per week.

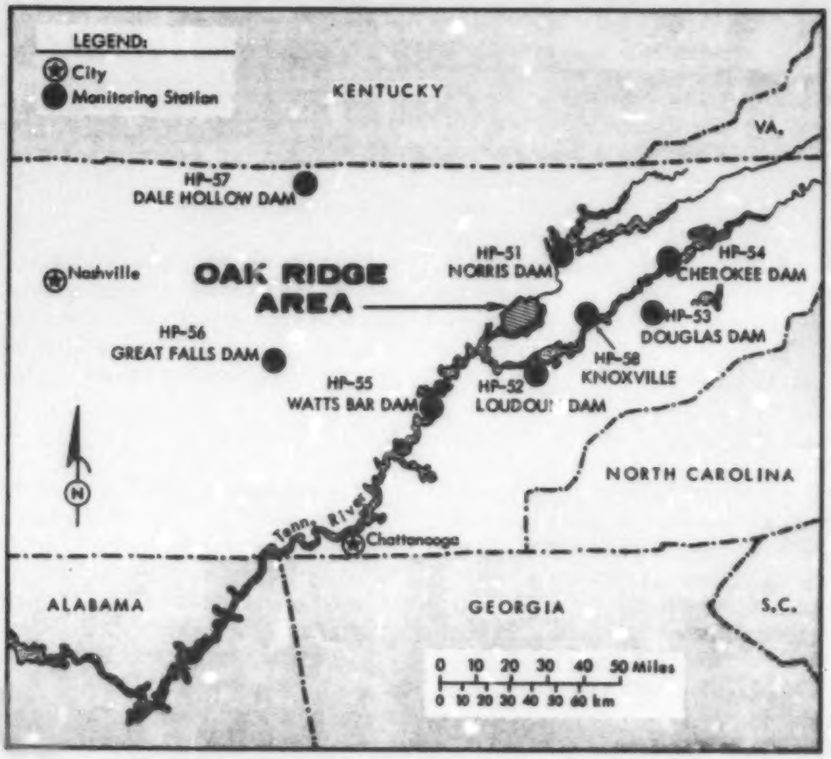
LEGEND:
City
Monitoring Station
KENTUCKY
VA.
HP-57
DALE HOLLOW DAM
Nashville
OAK RIDGE AREA
HP-51
NORRIS DAM
HP-54
CHEROKEE DAM
HP-53
DOUGLAS DAM
HP-56
GREAT FALLS DAM
HP-58
KNOXVILLE
HP-55
WATTS BAR DAM
HP-52
LOUDOUN DAM
NORTH CAROLINA
N
Tenn. River
Chattanooga
ALABAMA
GEORGIA
S.C.
0 10 20 30 40 50 Miles
0 10 20 30 40 50 60 km

Figure 2. Remote air monitoring stations, Oak Ridge area

sampling program is twofold: first, samples collected in the immediate vicinity of the Oak Ridge area provide data by which one may evaluate possible exposure to the neighboring population resulting from waste releases from Oak Ridge operations; second, samples collected at the more remote stations provide background data which are essential in establishing the proper index for the evaluation of data obtained from local samples. The concentrations of iodine-131 and strontium-90 detected in raw milk samples during the period are given in table 3.

Table 3. Radionuclides in raw milk, Oak Ridge area July–December 1969

Radionuclide and location	Concentration (pCi/liter)		
	Maximum	Minimum[a]	Average
Iodine-131			
Immediate environs	48	<10	<10
Remote environs	<10	<10	<10
Strontium-90			
Immediate environs	32	2.0	15
Remote environs	22	5.4	15

[a] The minimum detectable concentrations of iodine-131 and strontium-90 in milk are 10 pCi/liter and 2 pCi/liter, respectively. In averaging, one-half of the minimum detectable concentration was used for all samples showing an activity less than this concentration.

Water monitoring

Large volume, low-level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River system by way of White Oak Creek and the Clinch River. Liquid wastes originating at the ORGDP and Y-12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with AEC radiation protection standards. The radioactivity concentration from White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tenn. Stream gauging operations are carried on continuously to obtain dilution factors for calculating the probable concentrations of wastes in the river. Samples are analyzed for the long-lived beta-particle emitters, uranium, and the transuranic alpha-particle emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold-up time in the waste effluent system are such that short-lived radionuclides are normally not present. The average concentrations of major radionuclides in the Clinch River are given in table 4 for the period from July–December 1969.

Two quarterly composite water samples from the Clinch River were analyzed for uranium during this period. For these samples, the uranium concentrations were less than 1 pCi/liter, the level of detectability. The AEC radiation protection standard for natural uranium in water released to unrestricted areas is 20 nCi/liter.

Table 4. Concentrations of major radionuclides in the Clinch River, July–December 1969

Radionuclide	Average concentration (pCi/liter)		
	Location on Clinch River[a]		
	Mile: 23.1 (Upstream)	Mile: 20.8[b] (Outfall)	Mile: 4.5 (Downstream)
Strontium-90	1.3	0.8	0.7
Cerium-144	.2	<.1	<.1
Cesium-137	1.4	.2	1.2
Ruthenium-103-106	.4	.3	1.5
Cobalt-60	1.5	.1	.7
Zirconium-niobium-95	.3	<.1	.5
Tritium	NA	1,740	NA

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River (figure 1).

[b] The concentrations at Mile: 20.8 are not measured directly but the values are calculated based on the levels of waste released from White Oak Dam and the dilution provided by the Clinch River.

NA, no analysis.

Gamma measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above the ground. The results are shown in table 5.

Discussion of data

The average air contamination level for gross beta radioactivity, as shown by the continuous air monitoring filter data, for both the immediate and remote environs of the plants (figures 1 and 2) was 0.16 percent of the AEC radiation protection standard for uncontrolled areas.

The average air contamination levels for gross alpha radioactivity, as shown by the continuous air monitoring filter data, for the immediate and remote environs of the plants were 0.10 percent and 0.05 percent, respectively, of the AEC radiation protection standard for natural uranium for uncontrolled areas.

The average concentration of iodine-131 in air in the immediate environs of the plants was 0.01 pCi/m^3. This is approximately 0.01 percent of the AEC radiation standard for uncontrolled areas.

The average concentrations of iodine-131 in raw milk in the immediate and remote environs of the

Table 5. External gamma radiation levels,[a] Oak Ridge area, July–December 1969

Location	Radiation levels (mR/h)						
	July	August	September	October	November	December	Average
Kerr Hollow Gate	NA	0.012	0.012	0.010	0.012	0.013	0.012
Y-12, East Portal	NA	.011	.013	.011	NA	.018	.013
Newcomb Road	NA	.011	.012	.011	NA	.012	.012
Gallaher Gate	NA	.011	.010	.014	.010	.014	.014
White Wing Gate	NA	.011	.011	.010	.011	.011	.011

[a] The background in the Oak Ridge area, determined in 1943, was approximately 0.012 mR/h.
NA, no analysis.

Oak Ridge area were both less than 10 pCi/liter. These levels fall within the limits of FRC Range I if the average intake per individual is assumed to be 1 liter of milk per day.

The average concentration of strontium-90 in raw milk in both the immediate and remote environs of the controlled areas was 15 pCi/liter. The average falls within the limits of FRC Range I for transient rates of daily intake of strontium-90 for application to the average of suitable samples of an exposed population.

The percent maximum concentration of radioactivity in the Clinch River at Mile 20.8 (the point of entry of most of the wastes) and the measured average concentration at Mile 4.5 (near Kingston, Tenn.) were 0.39 percent and 0.25 percent, respectively, of the AEC radiation protection standards. The higher than normal concentration reported for radioactivity at Mile 23.1, Melton Hill Dam, was due primarily to cobalt-60. This contamination was found in the river upstream from the ORNL waste outfall and was the result of a source of contamination other than Oak Ridge operations. The average concentration of transuranic alpha particle emitters in the Clinch River at Mile 20.8 was 0.14 pCi/liter which is 0.14 percent of the AEC radiation protection standard for water containing a mixture of unknown radionuclides.

The average concentration of natural uranium materials in the Clinch River reflecting the effects of all Oak Ridge plants was less than 0.1 percent of the AEC radiation standard for uranium.

The average external gamma radiation measured in the town of Oak Ridge and at the perimeter of the Oak Ridge area was 0.012 mR/h, which is approximately the same as that level measured during the period prior to Oak Ridge operations.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1968	January 1970
January–June 1969	May 1970

2. Savannah River Plant[3]
July-December 1970

E. I. duPont de Nemours
Aiken, S.C.

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. duPont de Nemours and Company, occupies an area of 312 square miles along the Savannah River, 22 miles downstream from Augusta, Ga. Production facilities include a fuel preparation area, three reactors, two fuel separation areas, and a heavy water production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to ensure environmental concentrations below recommended guides.

A continuous monitoring program has been maintained since 1951 (before plant startup) to determine the concentrations of radioactive materials in a 1,200-square mile area outside the plant. Included in this area are parts of Aiken, Barnwell, and Allendale counties in South Carolina, and Richmond, Burke, and Screven counties in Georgia. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the AEC radiation protection standards as given in the AEC Manual.

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[3] Summarized from "Effects of the Savannah River Plant on Environmental Radioactivity," Semiannual Report, July–December 1970 (DPST–10–30–1).

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Plant-released radioactivity and atmospheric fallout are included in the reported concentrations. Maximum and minimum values given are for individual samples collected during the report period.

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by biweekly analyses of air filters collected at five monitoring stations near the plant perimeter and 10 stations around a circle of about 25 miles radius from the center of the plant (figure 3). Deposition rates of radioactive material at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant release of airborne radioactivity by SRP would be detected regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Ga., and at Columbia and Greenville, S.C., are so distant from SRP that the effect of SRP operations is negligible; they serve as reference points for determining background radioactivity levels (figure 4). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between fallout and SRP releases.

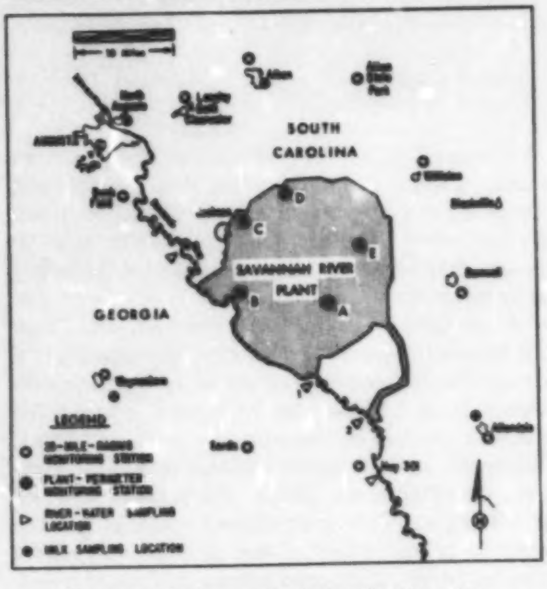

Figure 3. Environmental sampling locations, Savannah River Plant

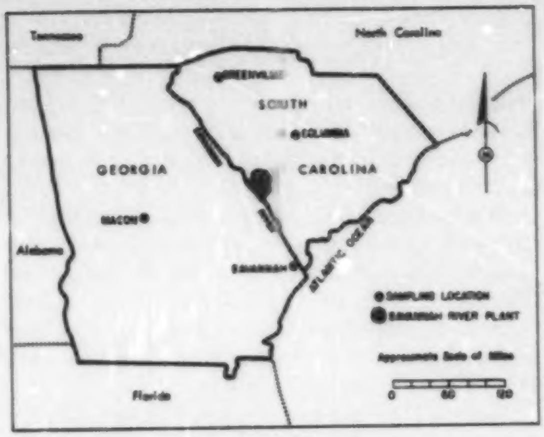

Figure 4. Distant air monitoring stations, Savannah River Plant

The small amount of filterable beta radioactivity released to the atmosphere, primarily from the fuel separation areas, was obscured by fallout. The influence of nuclear tests, which resumed in September 1961, is shown in figure 5. The present low levels of atmospheric activity are attributed to the moratorium on above ground nuclear tests, which began in 1962. The observed spring increases are anticipated and result primarily from the mixing of the stratospheric debris into the troposphere. The average beta concentration in air decreased from 0.26 pCi/m^3 to 0.17 pCi/m^3 during the last half of 1970. Gamma-emitting radionuclides in fallout were cesium-134–137, cerium-141–144, ruthenium-103–106, and zirconium-niobium-95.

Trace amounts of short radioactive-half-life materials were detected in routine air samples taken with a high volume air sampler. Nonplant origin of the radioactivity was indicated by the uniform levels found at all stations, both on and off the plant. The major component, beryllium-7, is a naturally occurring radionuclide formed by interaction of cosmic rays with oxygen and nitrogen in the upper atmosphere. Radioactivity in air, de-

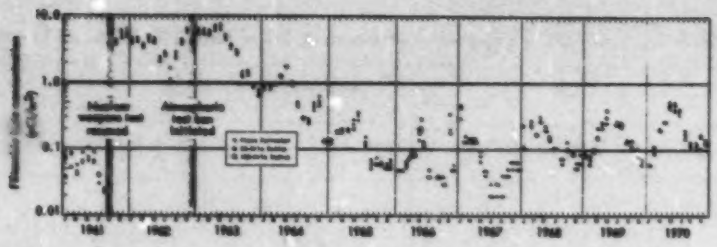

Figure 5. Influence of weapons tests

Table 6. Radioactivity in air, Savannah River Plant, July–December 1970

Sampling points	Alpha radioactivity[a] (fCi/m³)			Nonvolatile beta radioactivity[b] (pCi/m³)			Specific radionuclides in composite samples (pCi/m³)					
	Maximum	Minimum	Average	Maximum	Minimum	Average	^{89,90}Sr	^{137}Cs	^{141,144}Ce	^{103,106}Ru	^{95}Zr-Nb	^{7}Be
Plant perimeter:												
A	1.3	0.4	0.7	0.51	0.10	0.18	0.005	0.01	0.07	0.07	0.14	0.18
B	1.5	.4	.8	.66	.08	.14						
C	1.6	.4	.7	.61	.11	.19						
D	1.3	.5	.8	.95	.09	.22						
E	1.8	.4	.6	.46	.10	.18						
Average			.7			.18						
25-mile radius:												
Aiken Airport	1.4	.4	.7	.52	.13	.20	.005	.01	.06	.05	.12	.16
Aiken State Park	1.0	ND	.6	.46	.01	.16						
Allendale	3.0	.3	1.0	.41	.06	.17						
Barnwell	1.2	.3	.7	.46	.07	.18						
Bush Field	1.4	ND	.7	.56	.07	.17						
Langley	1.7	.4	.7	.68	.09	.20						
Sardis	1.0	.3	.6	.47	.06	.18						
Waynesboro	1.3	.3	.6	.50	.09	.18						
Williston	1.3	.4	.7	.54	.08	.19						
Highway 301	1.4	ND	.6	.49	.11	.20						
Average			.7			.18						
Distant air-monitoring:												
S.C.												
Columbia	1.4	ND	.9	0.59	.05	.14	.005	.01	.07	.34	.12	.18
Greenville	1.4	ND	.7	.58	.04	.18						
Ga.												
Macon	1.3	ND	.6	.52	.05	.15						
Savannah	1.0	ND	.5	.47	.04	.16						
Average			.7			.16						

[a] AEC radiation protection standard-70 fCi/m³.
[b] AEC radiation protection standard-100 pCi/m³.
ND, nondetectable.

termined from filter analyses, is shown in table 6. The July–December 1970 concentrations of filterable beta radioactivity (0.17 pCi/m³) and alpha radioactivity (0.7 fCi/m³) in air were 0.17 and 1.0 percent of the respective AEC standards. Tritium oxide concentrations in air, at the plant perimeter and at the 25-mile radius stations, did not exceed 0.2 percent of the AEC standard.

Deposition of fallout during July–December 1970 averaged 17 nCi/m² at the plant perimeter locations and 15 nCi/m² at 25-mile radius locations; comparable values for the last half of 1969 were 13 and 12 nCi/m² (excluding naturally occurring beryllium-7). Deposition at each sampling location is presented in table 7.

Water monitoring

The plant site is drained by five streams that flow several miles through the reservation before reaching the river (figure 6). The primary sources of the very small amount of radioactivity that reaches the river are the reactor facilities. The reactors are cooled and moderated by heavy water which, in turn, is cooled by river water in heat exchangers. This arrangement prevents irradiation of the river water so that radioactivity is discharged into the river water only on the rare occasions when small quantities of moderator are lost by heat exchanger leaks.

The irradiated fuel (canned to prevent leaching of radionuclides) discharged from a reactor is stored in a large, water-filled basin that is purged

Table 7. Total fallout deposited, Savannah River Plant, July–December 1970

Sampling points	Radioactivity concentration (nCi/m²)								
	Alpha[a]	Strontium-89	Strontium-90	Cesium-137	Cerium-141, 144	Zirconium-niobium-95	Beryllium-7[b]	Iodine-131	Ruthenium-103–106
Plant perimeter:									
A	4.4	1.3	0.5	0.8	6.4	4.8	14.7	1.6	1.1
B	2.8	.2	.5	.7	4.9	1.7	14.0	1.0	.8
C	5.0	.6	.7	.8	6.5	4.9	21.5	.7	2.5
D	5.9	.7	.5	.9	8.3	7.6	21.6	1.2	2.6
E	5.0	.9	.8	.9	7.6	5.8	22.5	1.6	1.8
Average	4.6	.8	.7	.8	6.7	5.0	18.9	1.2	1.8
25-mile radius:									
Aiken Airport	1.7	1.1	.5	.8	5.5	3.9	19.8	1.0	1.6
Aiken State Park	3.7	.5	.7	.7	7.5	5.0	21.7	1.6	1.5
Allendale	4.5	.8	.6	.6	7.9	5.2	24.7	1.9	2.1
Barnwell	1.5	.3	.5	.4	1.0	2.7	3.0	ND	1.4
Bush Field	2.3	ND	.7	.8	6.1	5.2	14.5	.8	.8
Langley	4.5	.8	.5	.8	6.2	4.6	19.1	.8	2.0
Sardis	2.6	1.0	.6	1.0	7.1	9.3	19.1	1.0	2.1
Waynesboro	5.5	.7	.7	1.1	7.4	5.6	21.0	.9	1.3
Williston	2.0	.2	.3	.3	5.5	2.2	12.4	1.9	ND
Highway 301	2.4	1.4	.6	.8	4.6	4.6	13.3	1.0	ND
Average	3.0	.7	.6	.7	5.9	4.8	16.9	1.1	1.3

[a] Multiple by 10^{-3}.
[b] A naturally-occurring radionuclide.
ND, less than the sensitivity of analysis.

to maintain clarity and to control water temperature. Newly discharged fuel is placed into an isolated section of the basin that is equipped with a water circulating system. Portable filters and deionizers are provided to remove a large percentage of the radionuclides, and a heat exchanger is used to control basin water temperature. Tritium from the irradiation of the D_2O moderator accounts for the largest quantity of radioactivity released by the reactors to the environment. However, the contribution to the Savannah River results in concentrations less than 1 percent of the AEC standard.

In January 1965, the Beaufort-Jasper Water Authority began operation of a treatment facility to furnish sanitary water, partially supplied from the Savannah River, to most of Beaufort County, S.C. Water is supplied through a canal from the river at a location about 90 miles below the Savannah River Plant. The city of Savannah also supplements its domestic well water supply with river water during periods of peak demand. The tritium concentrations in raw water collected from the Beaufort-Jasper Water Plant averaged 2.1 nCi/liter (0.07 percent of the AEC standard) during the July–December period. The annual radiation exposure of an individual in this population due to the consumption of 1.2 liters per day of water containing the very low concentration of tritium is 0.19 mrem, (this exposure may be compared with 20 mrem per year from natural potassium found in the body of all persons or with the 170 mrem per year specified by the Federal Radiation Council as the annual dose guide for members of the public).

Communities near the plant get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns were collected and analyzed in October. There was no evidence that SRP contributed radioactivity to drinking water supplies; concentrations of alpha radioactivity (1.1 pCi/liter) and beta radioactivity (5 pCi/liter) were essentially the same as those observed before plant startup. Specific analyses

Table 8. Radioactivity in public water supplies, July–December 1970

Sampling points	Alpha radioactivity[a] (pCi/liter)	Nonvolatile beta radioactivity[b] (pCi/liter)
Aiken	0.9	ND
Allendale	ND	ND
Augusta	1.0	8
Barnwell	ND	ND
Bath	1.8	ND
Blackville	.4	ND
Clearwater	ND	ND
Jackson	5.5	10
Langley	2.1	4
New Ellenton	1.0	ND
North Augusta	ND	9
Sardis	ND	ND
Waynesboro	ND	ND
Williston	1.5	ND
Average	1.1	5

[a] AEC radiation protection standard—10 pCi/liter; sensitivity of analysis—0.2 pCi/liter.
[b] AEC radiation protection standard—3 nCi/liter; sensitivity of analysis—4.0 pCi/liter.
ND, less than the sensitivity of analysis.

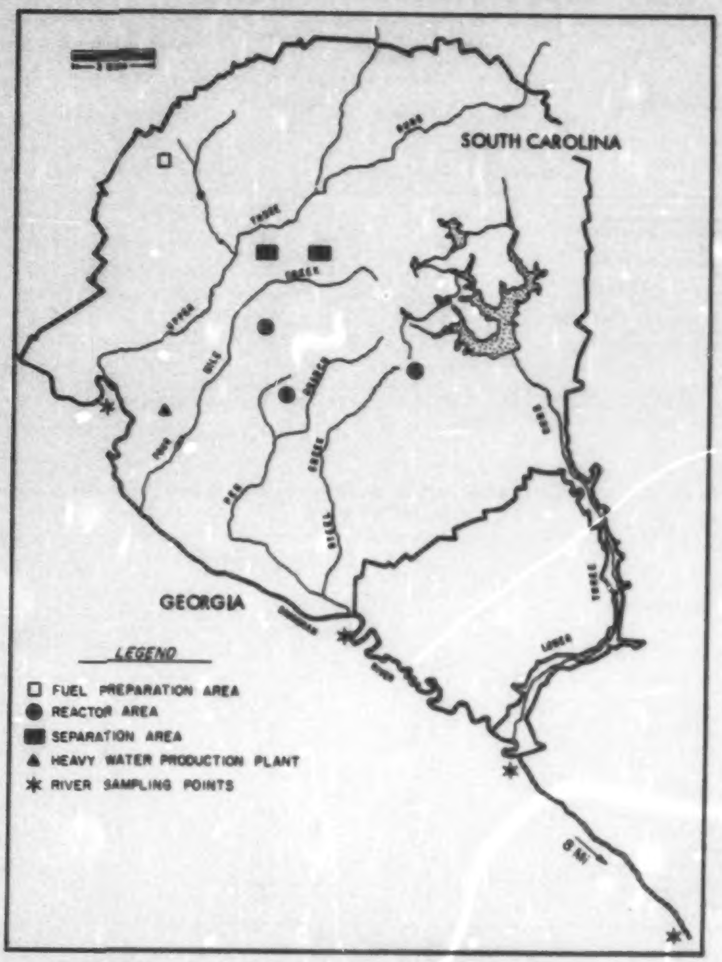
SOUTH CAROLINA
GEORGIA
LEGEND
☐ FUEL PREPARATION AREA
● REACTOR AREA
▬ SEPARATION AREA
▲ HEAVY WATER PRODUCTION PLANT
✱ RIVER SAMPLING POINTS
8 MI

Figure 6. SRP production and effluent streams

showed that the higher than average alpha activity found in some drinking water supplies (for example, 5.5 pCi/liter at Jackson) was due to naturally-occurring radioactivity, primarily thorium-228 and its short-lived daughter products. Radioactivity in public water supplies data is presented in table 8.

River water, analyzed weekly, was sampled continuously at four locations, as shown in figure 6. Concentrations of alpha and nonvolatile beta radioactivity in river water for the past year are presented in table 9. Average concentrations of specific radionuclides found in river water during July–December 1970 appear in table 10.

Tritium, sulfur-35, and trace amounts of cesium-137, strontium-89, and strontium-90 were the radionuclides of SRP origin detectable in river water at the downstream location. Strontium-90 and tritium from worldwide fallout were also detected in river water upstream from SRP effluents.

Tritium, a beta-particle emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavy water moderator in the reactors. The concentration of tritium in river water averaged 0.20 percent of the AEC standard.

Table 9. Radioactivity in Savannah River water, July–December 1970

Sampling point	Alpha radioactivity[a] (pCi/liter)				Nonvolatile beta radioactivity[b] (pCi/liter)			
	July–December 1970			January–June 1970	July–December 1970			January–June 1970
	Maximum	Minimum	Average	Average	Maximum	Minimum	Average	Average
1 mile upstream from Upper Three Runs Creek (control)	0.4	ND	ND	ND	8	ND	4	ND
Downstream from Steel Creek	.5	ND	ND	ND	26	ND	7	4
Downstream from Lower Three Runs Creek	.4	ND	ND	ND	16	ND	5	8
8 miles downstream from Lower Three Runs Creek (Highway 301)	.3	ND	ND	ND	15	ND	7	6

[a] AEC radiation protection standard—10 pCi/liter; sensitivity of analysis—0.2 pCi/liter.
[b] AEC radiation protection standard—3 nCi/liter; sensitivity of analysis—4.0 pCi/liter.
ND, less than the sensitivity of analysis.

Table 10. Average concentration of radionuclides in Savannah River water July–December 1970

Radionuclides	Concentration (pCi/liter)			
	Sensitivity	Control (1 mile upstream from Upper Three Runs Creek)	Highway 301 (8 miles downstream from Lower Three Runs Creek)	Percent AEC standard at Highway 301
Tritium	600	730	5,850	0.20
Sulfur-35	5.0	ND	4.1	.01
Chromium-51	4.2	ND	ND	<.001
Manganese-54	.4	ND	ND	<.0004
Cobalt-60	1.4	ND	ND	<.005
Zinc-65	1.1	ND	ND	<.001
Strontium-89	.3	ND	1.5	.05
Strontium-90	.01	.6	1.0	.33
Zirconium-niobium-95	.5	ND	ND	<.001
Ruthenium-103-106	2.2	ND	ND	<.03
Iodine-131	.2	ND	ND	<.07
Cesium-134-137	.6	ND	.9	.008
Barium-lanthanum-140	1.6	ND	ND	<.01
Cerium-141-144	2.5	ND	ND	<.02
Neptunium-239	2.2	ND	ND	<.002

ND, nondetectable, less than sensitivity of analysis.

Fish in Savannah River

Fish, predominantly bream, were collected weekly upstream, adjacent to, and downstream from Savannah River Plant effluents. Specific radionuclide analyses of fish are summarized in table 11. The radioactivity in bone and flesh from fish collected adjacent to and downstream from SRP indicates some minor contribution by SRP. Although measurably higher than similar collections at the control station upstream from SRP effluents, the increase is of minor significance when referenced against intake guides defined by the AEC radiation protection standard.

Table 11. Radioactivity in Savannah River fish July–December 1970

Location	Type of sample[a]	Concentration (pCi/g wet weight)			
		Strontium-89,-90		Cesium-137	
		Maximum	Average	Maximum	Average
Above plant boundary (control)	Bone	38	22	<2	<2
	Flesh	2	<1	<1	<1
Adjacent to plant	Bone	39	25	<2	<2
	Flesh	2	<1	3	2
Below plant at Highway 301	Bone	25	18	<2	<2
	Flesh	<1	<1	2	2

[a] Monthly composites of weekly collections for strontium-89, -90 and cesium-137.

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Vegetation

Radioactive contamination of growing plants may result from sorption of radioactive materials from the soil or from foliar deposition.

Grass samples were collected at seven locations along the plant perimeter and at seven other locations along a 25-mile radius route (these are not designated on figure 7). Bermuda grass was selected for analysis because of its importance as a pasture grass for dairy herds and its availability during all seasons of the year. Samples from each quadrant of the plant site and of the surrounding area were composited for monthly analysis. Gamma-emitting radionuclides in grass samples (excluding beryllium-7) were from fallout. Alpha-particle emitters averaged 0.1 pCi/g at the plant perimeter and at the 25-mile radius locations, the same as observed during the last half of 1969; gamma-ray emitters averaged 11.1 and 9.9 pCi/g, respectively, as compared to 12.0 and 15.3 pCi/g for the first half of 1969. Radioactivity in grass samples is presented in table 12.

Table 12. Radioactivity in vegetation, SRP July–December 1970

Radionuclides	Sensitivity of analysis (pCi/g dry weight)	Concentration (pCi/g dry weight)			
		Plant perimeter (7 locations)		25-mile radius (7 locations)	
		Maximum	Average	Maximum	Average
Alpha emitters	0.10	0.5	0.1	0.6	0.1
Cesium-137	.3	2.0	.7	.9	.5
Cerium-141, 144	1.0	9.9	4.3	5.3	3.6
Ruthenium-103, 106	1.4	ND	ND	ND	ND
Beryllium-7	3.0	10.2	4.8	8.2	4.4
Iodine-131	.2	ND	ND	.9	.2
Barium-lanthanum-140	6.0	ND	ND	ND	ND
Zirconium-niobium-95	.5	1.5	1.3	2.2	1.2

ND, less than sensitivity of analysis.

Milk

Milk was sampled at three dairies within a 25-mile radius of the Savannah River Plant (figure 7). Samples, collected biweekly, were analyzed for tritium and radioiodine. Strontium-90 and cesium-137 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during July–December 1970 are shown in table 13.

Average concentrations of the radionuclides in milk were 12 pCi/liter of strontium-90 and 40 pCi/liter of cesium-137 compared to 11 pCi/liter of strontium-90 and 20 pCi/liter of cesium-137 during the first half of 1970. Iodine-131 was less than the sensitivity of the analysis (5 pCi/liter) throughout this period. These values are consistent with those reported by the U.S. Public Health Service for most sections of the United States. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level (1,012 pCi/liter) was 0.03 percent of the AEC standard for water.

Environmental gamma radiation levels

Monthly measurements of environmental gamma radiation were made with thermoluminescent dosimeters. The July–December 1970 data (table 14) are characteristic of measurements observed at individual stations for the past several years.

Table 13. Radioactivity in milk from local dairies, Savannah River Plant July–December 1970

Distributing points	Tritium[a] (nCi/liter)			Strontium-90[b] (pCi/liter)		Cesium-137[c] (pCi/liter)	
	Maximum	Minimum	Average	September	December	September	December
Aiken	1.0	ND	0.4	9	11	31	33
North Augusta	3.0	0.9	1.7	19	21	59	66
Waynesboro	2.5	.4	1.1	7	8	34	34
Major distributors[d]	1.7	.4	.8	10	10	36	30

[a] Sensitivity of analysis—0.2 nCi/liter, AEC standard—3,000 nCi/liter.
[b] Sensitivity of analysis—1.0 pCi/liter, AEC standard—300 pCi/liter.
[c] Sensitivity of analysis—20 pCi/liter, AEC standard—20 nCi/liter.
[d] Milk produced in local dairies but sold by major distributors.
ND, nondetectable, less than sensitivity of analysis.

Table 14. Environmental gamma radiation, Savannah River Plant, July–December 1970

Sampling points	Gamma radiation (mR/24 h)		
	Maximum	Minimum	Average
Plant perimeter:			
A	0.24	0.16	0.19
B	.17	.13	.15
C	.21	.11	.15
D	.28	.12	.17
E	.16	.11	.14
Average			0.16
25-mile-radius:			
Aiken Airport	0.15	0.13	0.13
Aiken State Park	.16	.11	.13
Allendale	.21	.12	.16
Barnwell	.22	.14	.17
Bush Field	.23	.15	.18
Langley	.19	.13	.16
Sardis	.20	.12	.16
Waynesboro	.27	.10	.17
Williston	.21	.11	.16
Highway 301	.25	.14	.19
Average			0.16

Summary

The quantity of radioactive waste released by the Savannah River Plant to its environs was, for the most part, too small to be distinguished from natural background radiation or was obscured by fallout from offsite sources. Beta radioactivity in air, which had no relationship to plant operations, was about the same as that observed for the same period of 1969 and was 66 percent of the previous 6-month level. Radioactive materials in fish flesh continued to be far below levels considered significant from a health standpoint. The average concentration of any radionuclide in river water at Highway 301 did not exceed 0.3 percent of the AEC radiation protection standard.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1969	December 1970
January–June 1970	July 1971

Reported Nuclear Detonations, June 1971

(Includes seismic signals presumably from foreign nuclear detonations)

The U.S. Atomic Energy Commission announced that on July 1, 1971, the United States conducted an underground nuclear test at its Nevada Test Site which had a yield of less than 20 kilotons.

The Atomic Energy Commission also announced that an underground nuclear test with a yield of about 80 kilotons was conducted at its Nevada Test Site on July 8, 1971.

Seismic signals were recorded by the United States on July 10, 1971, presumably from a Soviet underground nuclear explosion. The signals originated on the western slopes of the Ural Mountains and were equivalent to those of an underground nuclear explosion in the yield range of 20 to 200 kilotons.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U. S. nuclear detonations may be obtained upon request from the Division of Public Information, U. S. Atomic Energy Commission, Washington, D. C. 20545.

☆ U.S. GOVERNMENT PRINTING OFFICE: – [illegible]

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 12, Number 9, September 1971

Radiological Health Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

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ENVIRONMENTAL PROTECTION AGENCY
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Reports

Preoperational Radiological Surveillance of the Florida Power Corporation's Crystal River Power Reactor Site

Chester L. Nayfield, Wallace Johnson, and *Benjamin P. Prewitt*[1]

Preoperational radiological surveillance has been conducted by the Florida Division of Health around the Crystal River nuclear power generating plant site of the Florida Power Corporation since May 1969. A summary of these data with reference to statistically significant differences between sampling locations is presented, and comparisons are made with other locations in the State for which data are available.

Preoperational radiological surveillance has been conducted around the Crystal River site of the Florida Power Corporation since May 1969 by the Florida Division of Health. Present activities at this site include a 387 MWe coal-fired generating unit and a 510 MWe coal-fired generating unit. Construction of unit three is underway. This unit is to be an 855 MWe nuclear power generating plant. Locations of Division of Health sampling sites are shown in figure 1. During 1969–1970, samples of environmental media shown in table 1 were collected.

Table 1. Number of environmental samples collected Crystal River

Vector	Number of samples		
	1969	1970	Total
Soil	79	68	147
Silt	16	14	30
Vegetation	79	126	205
Surface water	58	49	107
Drinking water	24	35	59
Marine biota	4	20	24
Milk	NS	2	2
Citrus	NS	5	5

NS, no sample.

Analyses of samples were conducted in the Radiological Laboratory of the Division of Health located in Orlando. Analytical instruments used included a 1,024 channel analyzer using a 4- by 4-inch NaI detector, a low-beta internal proportional counter, a beta internal proportional counter with automatic sample changer, and a Tri-Carb liquid scintillation spectrometer. The minimum detectable activities used in this laboratory for the various sample types are shown in table 2.

Table 2. Minimum detectable activities, Crystal River

Sample type	Alpha radioactivity	Beta radioactivity
Air	—	3.2 pCi/sample
Milk	—	1.2 pCi/liter
Soil and silt	3.4 pCi/g ash	1.1 pCi/g ash
Vegetation and biota	3.4 pCi/g ash	.78 pCi/g ash
Water	3.4 pCi/liter	.78 pCi/liter

For spectroscopy, a 9 by 9 matrix solution has been used in analyzing the samples. For soil and silt samples, the matrix was expanded to 11 by 11 to correct the spectum for the radium-thorium contribution. Minimum detectable activities for the various nuclides included in the 9 by 9 matrix are shown in table 3.

The selection of sampling media around the Crystal River site was dictated by the nature of the region. Since all of the Division of Health's surveillance is human-health oriented, every effort was made to confine sampling media as directly as possible to the human food-chain. This was difficult for the Crystal River area. The closest dairy is 15 miles from the plant site. This dairy is sampled although its contribution to the

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[1] Dr. Nayfield is an administrator, Radiological and Occupational Health Section, Florida Division of Health; Mr. Johnson is a public health physicist, Florida Division of Health; and Mr. Prewitt is a chemist, Bureau of Laboratories, Florida Division of Health.

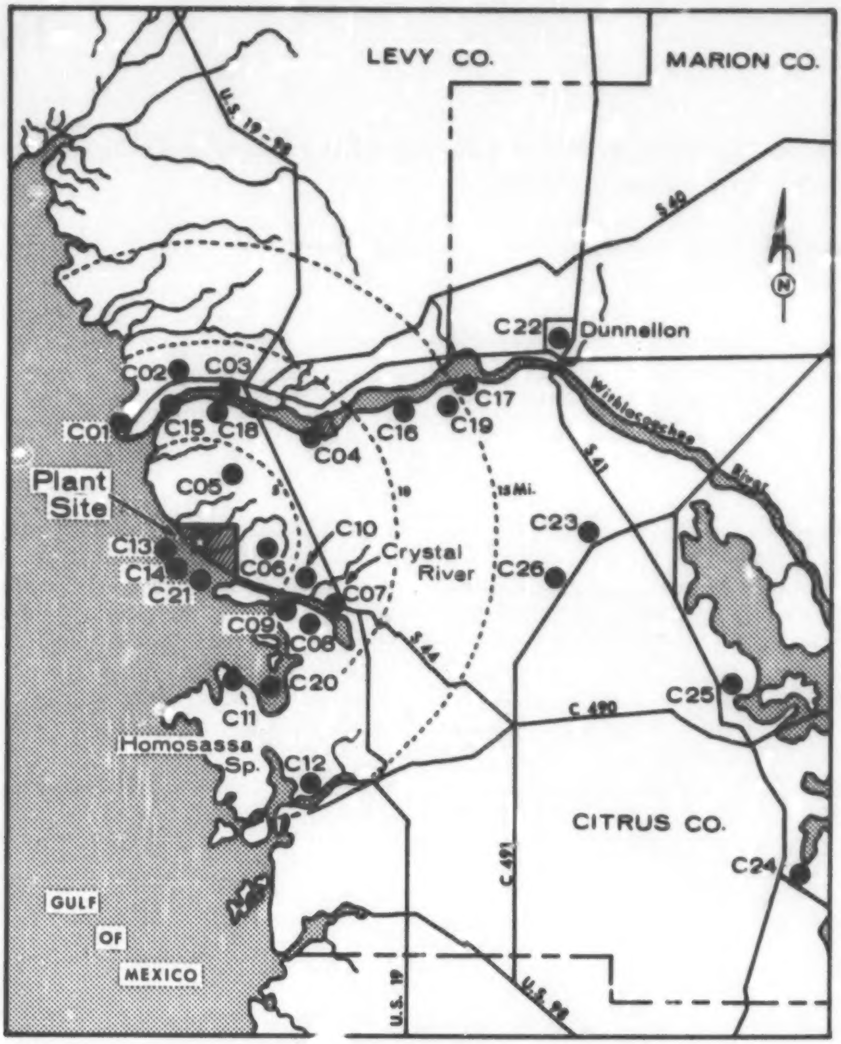
LEVY CO.
MARION CO.
U.S. 19-98
S 40
N
C22
Dunnellon
C02
C03
C01
C15
C18
C04
C16
C19
C17
Withlacoochee River
S 41
Plant Site
C05
5
10
15 Mi.
C10
Crystal River
C23
C13
C14
C21
C06
C07
C26
C09
C08
S 44
C20
C11
C25
C 490
Homosassa Sp.
C12
CITRUS CO.
C 491
C24
GULF
OF
MEXICO
U.S. 19
U.S. 98

Figure 1. Radiological sampling sites, Crystal River

Table 3. Minimum detectable activities for 9 by 9 matrix

Nuclide	Minimum detectable activity[a] (1 liter geometry)
Cerium-144	98.6 pCi
Iodine-131	18.5 pCi
Ruthenium-106	78.5 pCi
Cesium-137	17.4 pCi
Zirconium-niobium-95	14.6 pCi
Manganese-54	15.2 pCi
Zinc-65	32.0 pCi
Potassium-40	19.4 pCi
Barium-lanthanum-140	18.8 pCi

[a] A practical reporting level of the minimum detectable activity plus or minus 2 sigma is used for reporting the sampling data.

milkshed is of minimal significance. Row crops are not grown in the area other than on a home garden basis. A citrus grove, located about 75 miles from the plant site, is sampled. The cabbage palm (*Sabal palmetto*) and the saw palmetto (*Serenoa serrulata*) were selected as indicators in the terrestrial food chain. Cabbage palm hearts are a delicacy in Florida and are extensively eaten by some population groups. The saw palmetto and its berries constitute an element in the diet of deer, which have been found to have elevated body burdens of cesium-137 (*1*). Deer meat is in the direct human food chain.

Data for 1969 and 1970 for soil samples and vegetation samples are presented in tables 4 and 5.

An analysis of variance was made of these data for 1970 and the values obtained are shown in table 6. From these analyses it was concluded that the variance between sampling sites of soil samples is significant only for cesium-137. Significant differences are apparent for all nuclides in vegetation. Only gross beta radioactivity levels are not significantly different in vegetation.

Analysis of variance of vegetation samples by subgroups of sampling sites is of interest (table 7). For cesium-137 in vegetation there is no significant difference in sites 5–11 and the variation of significance is in group 1–4.

A comparison of sample means by year is of interest. See tables 8 and 9.

Table 4. Concentration of radionuclides in soil samples, Crystal River, 1969–1970

Sampling site and year	Radionuclide concentration (pCi/kg wet weight)									Radioactivity (pCi/g ash)	
	^{144}Ce	^{131}I	^{103}Ru	^{137}Cs	^{95}Zr	^{54}Mn	^{65}Zn	^{40}K	^{140}Ba	Gross beta	Gross alpha
C01:											
1969 Range...	540–1,100	ND	200–520	ND–130	ND–300	ND	ND	ND	ND	<10	<7
Mean...	562		320	104	167						
1970 Range...	400– 730	ND	ND	ND– 80	ND– 90	ND–30	ND	ND	ND	<10	<7
Mean...	490			40	52	[a]30					
C02:											
1969 Range...	380–1,700	ND	ND–1,500	70–580	40–1,200	ND	ND	ND	ND	<10	<7
Mean...	871		683	411	411						
1970 Range...	290– 770	ND	ND–440	ND–530	ND–200	ND	ND	ND	ND	<10	<7
Mean...	534		330	364	114						
C03:											
1969 Range...	430–1,000	ND	ND–570	100–830	40–330	ND–30	ND	ND	ND	<10	<7
Mean...	747		366	456	168	[a]30					
1970 Range...	ND–650	ND	ND–200	60–440	ND–110	ND	ND	ND	ND	<10	<7
Mean...	500		[a]200	211	53						
C04:											
1969 Range...	440–1,300	ND	ND–910	270–620	ND–510	ND	ND	ND	ND	<10	<7
Mean...	715		318	451	170						
1970 Range...	280– 780	ND	ND–390	120–680	30–150	ND	ND	ND	ND	<10	<7
Mean...	558		287	427	8[illegible]						
C05:											
1969 Range...	750–1,500	ND	ND–660	100–1,300	60–320	ND	ND	ND	ND	<10	<7
Mean...	960		308	616	141						
1970 Range...	440–1,400	ND	ND–370	340–1,000	ND–180	ND	ND	ND	ND	<10	<7
Mean...	751		300	587	89						
C06:											
1969 Range...	530–2,000	ND–100	ND–1,000	ND–1,900	ND–490	ND–60	ND	ND	ND	<10	<7
Mean...	1,204	[a]100	476	1,034	221	50					
1970 Range...	340– 900	ND–80	ND–740	ND–1,500	ND–100	ND	ND	ND	ND	<10	<7
Mean...	651	60	340	783	80						
C08:											
1969 Range...	360–1,900	ND	ND–1,700	ND–60	ND–1,200	ND	ND	ND	ND	<10	<7
Mean...	875		633	56	431						
1970 Range...	390–1,800	ND–100	ND–760	ND–2,100	ND–260	ND–50	ND	ND–550	ND	<10–62	<7–18
Mean...	1,221	85	580	1,415	200	43		482		38	15
C09:											
1969 Range...	490–1,400	ND	ND–1,300	ND	40–1,100			ND		<10	<7
Mean...	716		553		291						
1970 Range...	ND–720	ND	ND–380	ND–390	ND–150			ND		<10	<7
Mean...	553		[a]380	[a]390	64						
C11:											
1969 Range...	580–1,100	ND	ND–1,100	ND–420	50– 900	ND	ND	ND	ND	<10	<7
Mean...	725		340	354	165						
1970 Range...	540– 770	ND	ND–320	120–450	40–110	ND	ND	ND	ND	<10	<7
Mean...	636		247	321	69						
C12:											
1969 Range...	390–2,100	ND	ND–1,600	ND–580	40–1,200	ND–40	ND	ND	ND	<10	<7
Mean...	921		441	372	294	[a]40					
1970 Range...	ND–1,500	ND	ND–450	ND–1,000	ND–200	ND–50	ND	ND–540	ND	<10	<7
Mean...	1,050		317	486	100	[a]50		520			

[a] Only one observation above detectable level.
ND, nondetectable.

Table 5. Concentration of radionuclides in vegetation samples, Crystal River, 1969–1970

Sampling site and year	Radionuclide concentration (pCi/kg wet weight)									Radioactivity (pCi/g ash)	
	^{144}Ce	^{131}I	^{106}Ru	^{137}Cs	^{95}Zr	^{54}Mn	^{65}Zn	^{40}K	^{140}Ba	Gross beta	Gross alpha
C01:											
1969 Range	ND-590	ND	40-1,460	90-210	290-2,100	ND	ND	3,500-7,600	ND	133-281	<7-16
Mean	510		789	159	951			5,625		202	10
1970 Range	ND-1,300	ND	ND-850	130-500	30-1,100	ND	ND	3,700-8,700	ND	73-301	<7-24
Mean	835		515	452	360			5,461		167	15
C02:											
1969 Range	ND	ND	ND-370	370-1,500	70-1,100	ND	ND	5,600-7,400	ND	210-294	<7-19
Mean			483	714	452			6,443		244	10
1970 Range	ND	ND	ND-710	220-900	70-580	ND	ND	4,800-6,700	ND	112-255	<7-30
Mean			430	364	322			5,867		180	17
C03:											
1969 Range	ND-1,400	ND	ND-1,700	180-760	90-2,600	ND	ND	2,400-5,100	ND	124-193	<7-17
Mean	[a]1,040		726	410	1,255			3,087		163	10
1970 Range	ND-540	ND	ND-1,000	ND-370	ND-900	ND	ND-120	3,200-6,600	ND	74-272	<7-26
Mean	[b]540		573	233	297		[b]120	5,427		154	14
C04:											
1969 Range	ND	ND	ND-110	1,100-4,400	160-940	ND	ND	2,500-6,200	ND	63-314	<7-19
Mean			[b]110	2,475	412			3,687		174	12
1970 Range	ND	ND	ND-630	340-3,500	130-740	ND	ND	1,200-5,600	ND	93-243	<7-38
Mean			465	1,735	413			3,238		164	17
C05:											
1969 Range	ND-400	ND	350-1,500	300-1,400	310-2,000	ND	ND	4,000-7,400	ND	68-264	<7-22
Mean	[b]400		612	820	949			5,237		205	13
1970 Range	ND	ND	360-680	110-1,300	190-740	ND	ND	1,300-7,300	ND	69-207	<7-30
Mean			490	528	437			3,584		135	15
C06:											
1969 Range	ND	ND	ND-1,300	180-6,300	170-2,100	ND	ND	1,600-5,800	ND	109-229	<7-15
Mean			568	3,069	847			3,285		197	9
1970 Range	ND-390	ND	ND-360	170-4,000	70-510	ND-60	ND	3,000-7,300	ND	90-287	9-42
Mean	373		330	333	296	[b]60		4,918		187	16
C08:											
1969 Range	ND-110	ND	370-980	ND-250	240-1,400	ND	ND	3,900-6,700	ND	108-202	<7-13
Mean	[b]110		662	128	625			5,213		150	9
1970 Range	ND-350	ND	ND-700	ND-160	140-680	ND	ND	4,000-6,800	ND	72-218	<7-32
Mean	[b]350		526	103	346			4,940		147	13
C09:											
1969 Range	ND	ND	320-1,600	ND-140	150-770	ND	ND	4,900-7,100	ND	141-241	<7-10
Mean			759	110	549			5,938		178	8
1970 Range	ND	ND	ND-940	ND-160	ND-770	ND	ND	ND-7,000	ND	97-243	<7-26
Mean			507	102	369			5,236		164	13
C11:											
1969 Range	ND-730	ND	520-1,800	ND-160	280-3,000	ND	ND	3,600-6,600	ND	183-277	<7-21
Mean	526		1,077	131	1,331			5,225		233	13
1970 Range	ND-1,000	ND	360-860	80-280	230-1,300	ND	ND	3,400-6,900	ND	125-264	<7-26
Mean	750		619	152	693			5,058		179	17
C12:											
1969 Range	ND-430	ND	ND-870	100-330	180-1,800	ND	ND	2,600-7,500	ND	138-236	<7-14
Mean	[b]430		638	180	761			5,368		168	9
1970 Range	ND	ND	ND-510	ND-580	90-420	ND	ND	2,800-7,500	ND	104-234	<7-27
Mean			395	208	240			5,963		160	16

[a] Mean of two observations above detectable level.
[b] Only one observation above detectable level.
ND, nondetectable.

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Table 6. Results of the analysis of variance

Nuclide	Calculated F	95 percent F value	Conclusion
	Soil		
Cerium-144	0.0	2.25	Not significant
Cesium-137	7.5	2.25	Significant
Zirconium-95	1.3	2.25	Not significant
	Vegetation		
Cesium-137	21.1	2.01< F<2.09	Significant
Zirconium-95	2.4	2.01< F<2.09	Significant
Potassium-40	6.0	2.01< F<2.09	Significant
Gross beta	.27	2.01< F<2.09	Not significant

Table 7. Analysis of variance of vegetation samples by subgroups of sampling sites, Crystal River

Radionuclide	Calculated F	95 percent F value	Conclusion
Cesium-137:			
Sites 1–4	10.3	2.76< F<2.84	Significant
Sites 5–11	1.40	2.53< F<2.61	Not significant
Zirconium-95:			
Sites 1–4	.14	2.76< F<2.84	Not significant
Sites 5–11	3.97	2.53< F<2.61	Significant
Potassium-40:			
Sites 1–4	12.8	2.76< F<2.84	Significant
Sites 5–11	2.73	2.53< F<2.61	Significant
Gross beta:			
Sites 1–4	2.39	2.76< F<2.84	Not significant
Sites 5–11	.57	2.53< F<2.61	Not significant

Table 8. Soil sample means by radionuclide and by year, Crystal River, 1969–1970

Sampling site and year	Sample mean ($\overline{X}$)[a] (pCi/kg wet weight)			
	Cerium-144	Ruthenium-106	Cesium-137	Zirconium-95
C01:				
1969	562	320	104	167
1970	499	ND	40	52
C02:				
1969	871	683	411	411
1970	534	330	364	114
C03:				
1969	747	366	456	168
1970	500	200	211	53
C04:				
1969	715	318	451	170
1970	558	287	427	82
C05:				
1969	960	308	616	141
1970	751	300	587	89
C06:				
1969	1,204	476	1,034	221
1970	651	340	783	80
C08:				
1969	875	633	56	431
1970	1,221	580	1,415	200
C09:				
1969	716	553	ND	291
1970	553	380	390	64
C11:				
1969	725	340	354	165
1970	636	247	321	69
C12:				
1969	921	441	372	294
1970	1,050	317	486	100
$\overline{X}$:				
1969	830	444	428	246
1970	695	331	502	83

[a] Nondetectable sample results not included in mean.
ND, all sample results were nondetectable.

Utilizing the sign test statistic (*2*) and a one-sided test at a level of 0.05, it can be demonstrated that a statistically significant decrease took place in soil between 1969 and 1970 for all radionuclides, except cerium-144. Utilizing the same statistic, vegetation samples show a decrease in radionuclides except for cesium-137 and the naturally occurring potassium-40. Based on the physical half-life of these radionuclides (zirconium-95, 65.5 days; ruthenium-106, 368 days; cerium-144, 284 days; cesium-137, 30.0 years), this behavior is expected with the exception of the retention of cerium-144 in soil samples.

A comparison of these data with those obtained in the surveillance of the Cape Kennedy offsite environs is interesting. Unfortunately, the Cape Kennedy program was inactivated in early 1970 so that data are available for 1969 only. Examination of table 10 indicates one very striking difference between soil samples collected in the Crystal River program and those collected in the Cape Kennedy offsite programs. Potassium-40 has been essentially nondetectable in the Crystal River samples while it was detectable in nearly all of the Cape Kennedy samples. Utilizing the the Mann-Whitney "U" test (*3*), there is no significant difference between the cesium-137 levels in soil samples from the two programs at a 95-percent confidence level.

There is a significant difference in the means of cesium-137 levels between vegetation samples from Crystal River and Cape Kennedy. No significant difference is found between potassium-40 levels or between gross beta radioactivity levels. It is noted, however, that for cesium-137 there is no significant difference between the Cape Kennedy Zone A samples and the Crystal River samples. Zone A of the Cape Kennedy sampling plan is within a 10-mile radius of the launch site (figure 2) and corresponds in location with a majority of Crystal River sites (figure 1). The higher concentrations of cesium-137 occurred in Zone B (20 miles) and Zone C (30 miles) at Cape Kennedy. We conclude, therefore, that the

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Table 9. Vegetation sample means by radioactivity and by year, Crystal River, 1969–1970

Sampling site and year	Sample mean ($\bar{\bar{X}}$) (pCi/kg wet weight)				Sample mean ($\bar{\bar{X}}$)	
	Ruthenium-106	Cesium-137	Zirconium-95	Potassium-40	Gross beta (pCi/g ash)	Gross beta[a] (pCi/kg wet weight)
C01:						
1969	789	159	951	5,825	202	6,052
1970	515	452	360	5,461	167	5,305
C02:						
1969	483	714	452	6,463	244	6,731
1970	430	564	322	5,867	180	5,484
C03:						
1969	726	410	1,255	3,087	163	4,620
1970	573	233	297	5,427	154	4,915
C04:						
1969	110	2,475	412	3,687	174	4,399
1970	465	1,735	413	3,238	164	3,841
C05:						
1969	612	829	949	5,237	205	5,754
1970	490	526	437	3,584	135	3,968
C06:						
1969	568	3,069	847	3,285	197	5,124
1970	330	333	296	4,918	187	4,840
C08:						
1969	662	128	625	5,213	150	5,115
1970	526	103	346	4,940	147	5,583
C09:						
1969	759	110	846	5,938	178	6,048
1970	507	102	309	5,236	164	5,255
C11:						
1969	1,077	131	1,331	5,225	233	5,706
1970	619	152	693	5,058	179	5,122
C12:						
1969	638	180	761	5,368	168	5,003
1970	395	208	240	5,963	160	4,957
$\bar{\bar{X}}$:						
1969	642	819	713	4,933	191	5,521
1970	485	441	377	4,969	164	4,927

[a] Not reported in table 5.

Table 10. Cape Kennedy offsite data compared to Crystal River data for 1969

Location	Soil (pCi/kg wet weight)					Vegetation				
						Gross beta (pCi/g ash)	(pCi/Kg wet weight)			
	^{144}Ce	^{106}Ru	^{137}Cs	^{95}Zr	^{40}K		^{106}Ru	^{137}Cs	^{95}Zr	^{40}K
Zone A composite	1,346	270	193	100	1,220	233	1,500	600	2,000	5,800
Zone B composite	779	315	244	87	746	195	990	2,770	805	3,075
Zone C composite	1,302	254	324	116	1,092	188	995	1,500	623	2,866
Cape Kennedy grand mean	1,142	279	254	101	1,019	208	1,161	1,623	1,143	3,910
Crystal River grand mean	830	444	428	246	[a]501	191	642	819	713	4,933
Division of Health Bureau of Sanitary Engineering sampling						178	890	1,080	773	4,666

[a] Two sampling locations only; all other samples were nondetectable.

elevated levels of cesium-137 demonstrated in palmetto at sites 4, 5, and 6 at Crystal River in 1969 and at sites 4 and 5 in 1970, are representative of more inland locations such as those of Zone B and Zone C at Cape Kennedy.

The levels of radionuclides in vegetation taken at Crystal River in 1969 show a much closer correlation to samples taken in 1969 by the Bureau of Sanitary Engineering of the Division of Health in Seminole and Volusia Counties than to those from the Cape Kennedy area. The Seminole County and Volusia County samples were analyzed by the Orlando Radiological Laboratory as were the Crystal River samples. Utilizing the "Student's t" distribution at a 95-percent confidence level, there is no significant difference between the means of cesium-137 from the respective locations.

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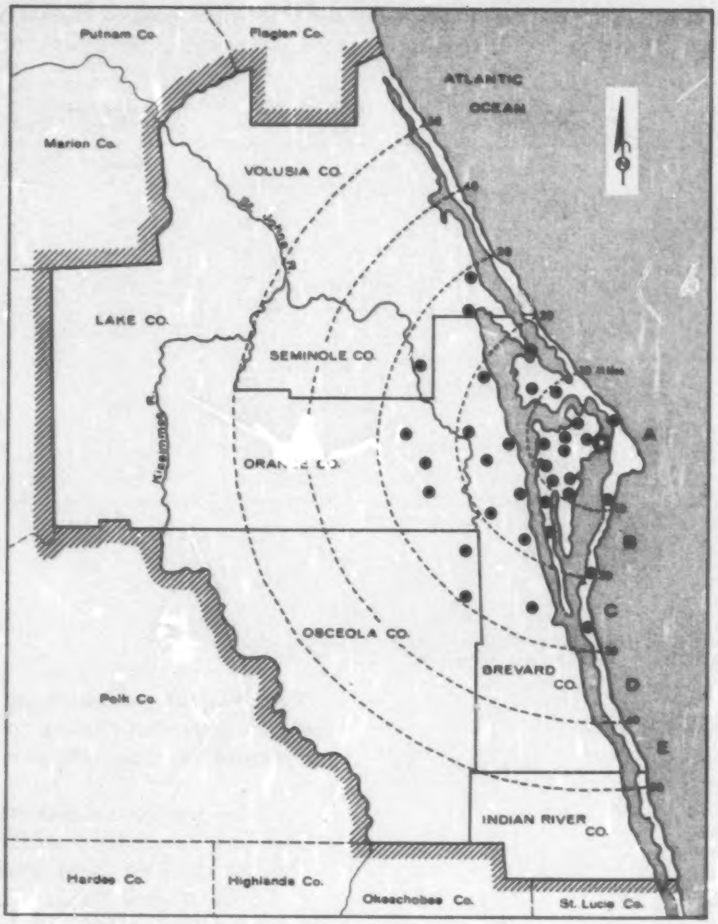
Putnam Co.
Flagler Co.
ATLANTIC OCEAN
Marion Co.
VOLUSIA CO.
St. Johns R.
LAKE CO.
SEMINOLE CO.
Kissimmee R.
ORANGE CO.
OSCEOLA CO.
BREVARD CO.
Polk Co.
INDIAN RIVER CO.
Hardee Co.
Highlands Co.
Okeechobee Co.
St. Lucie Co.
50
40
30
20
10 Miles
A
B
C
D
E

Figure 2. Cape Kennedy fixed offsite sampling areas

Levels of radioactivity in water samples are shown in table 11. Levels of activity in drinking water derived from wells have been nondetectable for 1969 and 1970 (table 12). Surface water samples are taken over a wide range of sources with varying salinities. Undissolved solid gross beta radioactivity levels have been nondetectable for all of the samples taken in 1969 and 1970. Levels of gross beta radioactivity in dissolved solids are dependent on the salinity of the water and have ranged from 5 to 495 pCi/liter. Potassium-40 is the only radionuclide which has been found in water in detectable concentrations by gamma analysis, and only at site C13 (intake canal) and site C14 (discharge canal). The normal level of potassium-40 in seawater of 35 parts per thousand salinity is reported to be 330 pCi/liter (4). There were no detectable concentrations of tritium (minimum detectable concentration = 200 pCi/liter) in any of the water samples.

Levels of radioactivity detected in various marine biota in 1970 are outlined in table 13. Levels of the various radionuclides from fish samples may be compared to those detected in fish samples taken from the Turkey Point surveillance program (table 14). It is noted that

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Table 11. Sample means of gross beta radioactivity in surface water samples, Crystal River, 1969–1970

Sampling location	1969			1970		
	Undissolved solids (pCi/liter)	Dissolved solids (pCi/liter)		Undissolved solids (pCi/liter)	Dissolved solids (pCi/liter)	
	Mean	Mean	Range	Mean	Mean	Range
C01: Mouth of Withlacoochee	<10	50	5–137	<10	48	19–130
C06: Tide Flat	<10	39	10–96	<10	23	10–51
C09: Crystal River	<10	104	56–162	<10	58	26–73
C11: Open Gulf	<10	143	99–207	<10	109	43–193
C12: Homassassa River	<10	25	8–101	<10	9	8–15
C13: Intake canal	<10	249	112–495	<10	152	123–214
Potassium-40		270	220–310		223	190–280
C14: Discharge canal	<10	201	127–430	<10	210	52–271
Potassium-40		232	ND–310		253	240–280
C16: Withlacoochee River	<10	<10		<10	<10	
C17: Withlacoochee River	<10	<10		<10	<10	

Table 12. Sample means of gross beta radioactivity in drinking water samples, Crystal River, 1969–1970

Sampling location	1969		1970	
	Undissolved solids (pCi/liter)	Dissolved solids (pCi/liter)	Undissolved solids (pCi/liter)	Dissolved solids (pCi/liter)
C07: Crystal River City well	<10	<10	<10	<10
C10: Indian waters well	<10	<10	<10	<10
C18: Yankeetown City well	<10	<10	<10	<10
C24: City of Inverness well			<10	<10
C22: City of Dunnellion well			<10	<10
C23: Holder deep well			<10	<10

there is a good agreement between means of potassium-40 as would be expected. Testing the means of gross beta with the "Student t" distribution (*5*) at a 95-percent confidence level indicates a significant difference. The difference between means of cesium-137 is apparent. Other radionuclides were generally nondetectable in both programs.

A comparison of oyster samples collected at the Crystal River site in 1970 may be made with samples taken from Apalachicola Bay during the same period (table 15).

Conclusion

A number of conclusions may be drawn from the data presented relative to the preoperational distribution of radionuclides in the Crystal River area.

1. There has been a reduction in the levels of artificial radionuclides present in the environment except for the long half-life cesium-137.

2. Levels of radionuclides in soil are not significantly different from control locations (Cape Kennedy offsite sampling sites) except for levels of potassium-40 which appear to be lower than those of the control locations.

3. Levels of radionuclides in vegetation are not significantly different from levels of comparable control locations (Cape Kennedy offsite sampling sites). Despite differences in potassium-40 levels in soil, levels of potassium-40 in vegetation are not significantly different between Crystal River and comparable control locations.

4. Gross beta radioactivity levels in surface water are highly dependent on the salinity of the water. Comparisons of sampling locations will require normalization to the salinity levels to be significant.

5. A significant difference exists between levels of gross beta radioactivity in fish samples taken at Crystal River and those taken at Turkey Point,

Table 13. Levels of radionuclides detected in marine biota, Crystal River, 1970

Sampling site and vector	Radioactivity (pCi/kg wet weight)					
	^{144}Ce	^{106}Ru	^{137}Cs	^{95}Zr	^{40}K	Beta[a] (pCi/g ash)
Crab:						
C01	200	ND	210	100	2,000	<10
C21	640	ND	90	ND	2,000	14
	220	ND	ND	40	1,500	<10
C20	600	ND	110	30	2,800	21
C13	310	ND	90	80	1,700	16
	ND	ND	ND	ND	1,400	20
Mean	394	ND	125	62	1,900	15
Oysters:						
C14	ND	ND	ND	30	2,300	11
	ND	ND	80	ND	2,500	57
	ND	360	ND	ND	1,900	11
C13	ND	ND	ND	ND	ND	52
C11	ND	ND	ND	30	1,200	87
C08	ND	ND	ND	ND	ND	43
Mean	ND	360	80	30	1,975	43
Fish:						
C21	ND	ND	ND	ND	1,200	24
Redfish:						
C20	ND	ND	ND	ND	2,300	41
C14	ND	ND	ND	ND	2,700	52
Mullet:						
C01	ND	ND	ND	ND	2,400	70
C11	740	ND	130	ND	3,700	59
	ND	ND	ND	ND	2,700	26
	ND	ND	ND	ND	2,000	67
Mean	740	ND	130	ND	2,428	48

[a] Beta, <10 pCi/g ash averaged as 10 pCi/g ash.
ND, nondetectable, not included in average.

Table 14. Comparison of mean levels of radionuclides in fish samples, Crystal River—Turkey Point, 1970

Radioactivity	Crystal River mean	Turkey Point mean
Potassium-40 (pCi/kg wet weight)	2,428	2,511
Gross beta (pCi/g ash)	48	36
Cesium-137 (pCi/kg wet weight)	[a]130	68

[a] Only one detectable observation.

Table 15. Comparison of oyster samples, 1970

Radioactivity	Crystal River mean	Apalachicola Bay mean
Gross beta (pCi/g ash)	43 (6 samples)	49 (4 samples)
Potassium-40 (pCi/kg wet weight)	1,975	1,946

There is no significant difference between the means for gross beta radioactivity or between the means for potassium-40.

with Crystal River higher. There is no significant difference between gross beta radioactivity levels in oyster samples taken from Crystal River and from Apalachicola Bay.

6. Differences in cesium-137 levels in vegetation samples taken from certain sampling sites are significant when compared to other sampling sites at Crystal River. The levels are not significantly different from levels in vegetation at control locations in other similar geographic areas.

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Evaluation of the Sampling Frequency of the Pasteurized Milk Network

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The Pasteurized Milk Network (PMN) of the Environmental Protection Agency reduced its milk sampling frequency from weekly to monthly in July 1970. A review of the effect of this reduced sampling frequency from a statistical viewpoint, on the capability of the network to carry out the surveillance requirements outlined by guides of the Federal Radiation Council, was preformed. The study determined that, based on the presently accepted radiation protection guides, the reduced frequency of milk collection does not sacrifice the precision required for a public health evaluation of current levels of radionuclides in the nation's pasteurized milk supply.

The pasteurized milk surveillance program had its origin in a raw milk radiological monitoring network established by the U.S. Public Health Service (PHS) in 1957. Primary objectives of this program included the development of methods for milk collection and radionuclide analysis suitable for large scale programs. Experience derived from this study led to the development of the present milk surveillance network.

The Pasteurized Milk Network (PMN), as it is now constituted, consists of 63 sampling stations, with at least one station located in each State, Puerto Rico, the Canal Zone, and the District of Columbia. The Western Environmental Research Laboratory (WERL) is responsible for the analysis of samples from 23 of the PMN stations located in the Western United States. The objectives of the PMN are to: (1) provide continuing nationwide measurement of radionuclide levels in pasteurized milk through sampling of major milk production and consumption areas, and (2) to supply information on concentration levels and trends from which local, State, and federal agencies can determine the need for further investigation and possible corrective action for the protection of public health.

Each PMN sample is a composite of subsamples from each milk processing plant in the particular area. Compositing is done in proportion to each plant's average sales in the community. At most stations, the composite sample represents at least 80 percent of the milk processed, and the overall network represents milk consumed by about 60 million persons.

Samples are analyzed by gamma scintillation spectroscopy for potassium-40, iodine-131, cesium-137, and barium-140, along with any other gamma-emitting nuclides present in appreciable concentrations. Radiochemical analysis is performed to determine the levels of strontium-89 and strontium-90.

Prior to July 1, 1970, samples were collected on a weekly basis. All samples were analyzed by gamma scintillation spectroscopy, and strontium-90 analysis was performed on samples collected during the first full week of each month. At WERL, strontium-89 is determined in the same analysis as strontium-90, and therefore, the frequency of analysis is the same.

On July 1, 1970, the collection frequency for the PMN was changed from weekly to monthly. Gamma scintillation spectroscopy is performed on all samples and strontium-90 analysis is performed quarterly except at certain designated stations. Samples from 12 designated stations in the PMN are analyzed for strontium-89 and strontium-90 on a monthly basis; one sample is a special milk sample collected from a non-PMN station.

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Purpose and scope

The observance of consistently low levels of the radionuclides monitored resulted in the reduced sampling and analysis frequency. This paper describes a review of the effect of the reduced sampling frequency from a statistical viewpoint, to determine wether the surveillance requirements as outlined by guides of the former Federal Radiation Council (FRC)[2] will be met. In all cases for the past several years, radionuclide levels in PMN samples have been well below the radioactivity concentration guide (RCG) for individuals in the general population as defined by the FRC (*1–2*). The FRC established three ranges of nuclide intake levels for which increasing amounts of action must be taken in order that the Radiation Protection Guides not be exceeded. Intakes in Range I would not, under normal conditions, be expected to result in any appreciable number of individuals in the population reaching a large fraction of the RPG. Therefore, if calculations based upon a knowledge of the sources of release of radioactive materials to the environment indicate that intakes of the population are in this range, the only action required is surveillance adequate to provide reasonable confirmation of calculations (*2*). Table 1 presents a summary of the FRC guidelines as they relate to the nuclides monitored by the PMN.

Since the principal contributor of fission products observed in samples is atmospheric testing of nuclear devices, and since the scope of such testing has been drastically curtailed since the signing of the limited test ban treaty on August 5, 1963, it is not difficult to explain the current relatively low levels of fission product activity.

Procedure

For the purposes of this study, the results from five of the 23 PMN stations monitored by WERL were examined. Two stations were chosen from predominately "wet" areas, two from "dry" areas, and one where rainfall is intermediate between the two extremes (*3*). The stations selected represented a good geographic distribution from the Pacific Coast to the Mississippi River, and from the northern to the southern tier of States. The stations chosen are:

Phoenix, Arizona
Minneapolis, Minnesota
St. Louis, Missouri
Portland, Oregon
Salt Lake City, Utah

For each station, recent data (1969) were obtained on levels of cesium-137, strontium-89, and strontium-90. Because of the short half-lives of iodine-131 and barium-140, and the absence of large-scale atmospheric nuclear testing since the signing of the limited test ban treaty, positive identification of iodine-131 or barium-140 in PMN samples has been infrequent in recent years. Average concentrations for cesium-137 and strontium-90

Table 1. Radiation Protection Guides, FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/a)	Guidance for suitable samples of exposed population groups[a]				
			RPG (rad/a)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	[c]1.5	0.5	[d]2,000	0–200	200–2,000	2,000–20,000
	Bone marrow	[c].5	.17				
Strontium-90	Bone	[c]1.5	.5	[d]200	0–20	20–200	200–2,000
	Bone marrow	[c].5	.17				
Iodine-131	Thyroid	1.5	.5	100	0–10	10–100	100–1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0–360	360–3,600	3,600–36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.
[b] Based on an average intake of 1 liter of milk per day.
[c] A dose of 1.5 rad/a to the bone is estimated to result in a dose of 0.5 rad/a to the bone marrow.
[d] For strontium-89 and strontium-90 the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.
[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

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[2] The responsibilities of the Federal Radiation Council were transferred to the Environmental Protection Agency by President Nixon's Reorganization Plan Number 3, effective December 2, 1970. The guides of the former FRC are referred to as FRC guides in this paper.

for the five stations did not vary significantly from the PMN network averages for the same time period (*4*).

The approach to the problem was to determine statistically, the sampling and analysis frequency needed to indicate, with reasonable confidence, present levels of the nuclides under study that would not be mistaken as exceeding FRC Range I. The one-sided t-test was used to evaluate the sampling frequency (*5*). This procedure utilizes the knowledge of past variability of the parameter being studied to estimate the number of samples needed to estimate current values to a specified accuracy and with a known degree of confidence. The calculation of the number of samples required is given in equation 1:

$$n = \frac{t^2 s^2}{d^2} \qquad \ldots(1)$$

where

t = value from table of "percentiles of the t distribution" for the specified risk level and the appropriate degrees of freedom $(n - 1)$,

s^2 = estimate of the variance of the population based on variance of data from prior or similar surveys, and

d = allowable margin of error in the estimate of the population mean.

This equation can be rewritten in terms of the coefficient of variation and an allowable percent departure from the true mean. This equation is given in 2:

$$n = \frac{(CV)^2 t^2}{p^2} \qquad \ldots(2)$$

where

n = number of samples,

t = same as for equation 1,

(CV) = coefficient of variation

$$= \frac{\text{standard deviation}}{\text{mean}} \times 100, \text{ and}$$

p = allowable percent departure from the true mean.

This equation may also be rewritten as follows:

$$p = \frac{(CV)t}{\sqrt{n}} \qquad \ldots(3)$$

This equation, based on a set number of samples per year and a predetermined confidence level (95 percent for purposes of this study) gives the percent accuracy with which the mean could be determined.

Results

The results of the statistical analysis of cesium-137, strontium-89, and strontium-90 data from the PMN stations studied are presented in tables 2, 3, and 4. The first and second columns, respectively, show the sample mean and the standard deviation based on the 1969 data. Column 3 shows the upper limit on radionuclide concentrations allowed under FRC guidelines for Range I surveillance. Column 4 gives the maximum tolerable error in the determination of the 1969 mean which still allows it to remain within Range I. This figure was calculated by dividing the limit in column 3 by the mean in column 1 and converting to a percentage. Columns 5 through 7 show the range of the percentage departure from the true mean provided by weekly, monthly, and quarterly sampling calculated using formula 3. The meaning of the percentage departure from the true mean is that, at the confidence level indicated (95 percent), the true mean is expected to lie within the range of the measured mean plus or minus the percent deviation shown in these columns. [μ (true mean) lies within $\bar{X}$ (observed mean) $\pm \frac{P\bar{X}}{100}$ (P = percent departure from the observed mean).]

Discussion of results

It can be seen from tables 2–4 that the most critical nuclide under consideration is strontium-90. In the case of both cesium-137 and strontium-89, the upper limit of FRC Range I exceeds the calculated sample means by at least one order of magnitude. Even in the case of the strontium-90, the precision provided by data from monthly or quarterly sampling is sufficient to evaluate the current levels. For cesium-137 and strontium-89, most of the means calculated using raw data were below the established minimum detectable concentration.

Table 2. Cesium-137

Station		1969 $\bar{X}^a$ (pCi/liter)	1969 s (pCi/liter)	Upper limit FRC Range I (pCi/liter)	Maximum tolerable percent error to remain in Range I	Percent departure (±) from true mean[b] provided by: Weekly sampling	Monthly sampling	Quarterly sampling
Ariz:	Phoenix	1.96	2.40	360	18,400	34	71	120
Minn:	Minneapolis	12.44	4.37	360	2,900	10	20	35
Mo:	St. Louis	6.24	4.86	360	5,900	22	46	80
Oreg:	Portland	10.15	5.21	360	3,500	14	30	52
Utah:	Salt Lake City	7.83	5.13	360	4,600	18	38	65

[a] Raw data (not rounded off to reflect minimum detectable concentration) were used to compute averages, with the exception that negative calculated values were converted to zero.
[b] Calculated from equation (3) at 95-percent confidence level.

Table 3. Strontium-89

Station		1969 $\bar{X}^a$ (pCi/liter)	1969 s (pCi/liter)	Upper limit FRC Range I (pCi/liter)	Maximum tolerable percent error to remain in Range I	Percent departure (±) from true mean[b] provided by: Weekly sampling	Monthly sampling	Quarterly sampling
Ariz:	Phoenix	0.67	0.89	200	30,300	41	86	150
Minn:	Minneapolis	3.58	5.43	200	5,600	46	96	170
Mo:	St. Louis	3.50	3.34	200	5,700	29	61	110
Oreg:	Portland	3.00	2.95	200	6,700	30	62	110
Utah:	Salt Lake City	1.17	2.44	200	17,100	64	130	230

[a] Raw data (not rounded off to reflect minimum detectable concentration) were used to compute averages, with the exception that negative calculated values were converted to zero.
[b] Calculated from equation (3) at 95-percent confidence level.

Table 4. Strontium-90

Station		1969 $\bar{X}^a$ (pCi/liter)	1969 s (pCi/liter)	Upper limit FRC Range I (pCi/liter)	Maximum tolerable percent error to remain in Range I	Percent departure (±) from true mean[b] provided by: Weekly sampling	Monthly sampling	Quarterly sampling
Ariz:	Phoenix	1.48	0.80	20	1,350	16	34	59
Minn:	Minneapolis	10.17	2.09	20	197	6	13	23
Mo:	St. Louis	8.13	1.50	20	250	6	12	20
Oreg:	Portland	6.30	2.65	20	313	13	26	46
Utah:	Salt Lake City	4.60	2.30	20	430	15	32	55

[a] Raw data (not rounded off to reflect minimum detectable concentration) were used to compute averages, with the exception that negative calculated values were converted to zero.
[b] Calculated from equation (3) at 95-percent confidence level.

Conclusions

From the statistical analysis performed, it is obvious that data provided by the current PMN sampling frequency does not sacrifice the precision required for a public health evaluation of current levels of radionuclides in the nation's pasteurized milk supply, based on the presently accepted radiation protection guides. Based on statistics alone, if concentrations in samples were higher and were stable over a period of time, the coefficient of variation would be smaller and the number of samples needed would be less. However, in a transition period, or a period of variability, the coefficient of variation would be larger, indicating a need for more frequent sampling.

In all cases, the accuracy provided by the current sampling frequency is more than adequate to confirm that the current levels are within the FRC Range I. Selection of sampling frequency, however, is based not only on radionuclide concentration, but also upon operational considerations.

Procedural considerations are also important in determining sampling frequency. In the case of the PMN, one very important factor is network efficiency. The network efficiency is the capability of the network to collect samples in the prescribed manner and submit them to the laboratory for analysis within the established time schedule. Past experience has shown that as the sampling frequency is decreased, so is the collection efficiency. Although environmental levels of the nuclides surveyed are low, readiness to increase the collection and analysis frequency to meet FRC requirements must be maintained in the event that there is a significant increase in fission product levels.

The current sampling and analysis frequency appears to be appropriate for the PMN under the present circumstances.

REFERENCES

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Technical Notes

Results of a Followup Radiation Survey on Color Television Sets, Suffolk County, New York

Seymour Becker[1]

The U.S. Public Health Service's regulatory standard required that television receivers manufactured after January 15, 1970, produce no radiation exceeding an exposure rate of 0.5 mR/h at 5 cm from any point on the external surface of the receiver (*1*). As part of a continuing survey of color television receivers in Suffolk County, New York, the Suffolk County Department of Health, at the owners' request, inspected approximately 150 television receivers that had been purchased after January 1, 1970. In spite of the fact that some of these receivers were manufactured before January 15, 1970, and therefore were not required to meet the regulation, no levels of x-radiation were detected above 0.5 mR/h at 5 cm from the surface of the television receiver. In fact, no levels of x radiation were detected above natural background radiation at the television set owner's homes.

A followup survey was also conducted on some of the television receivers that had previously been adjusted or modified during the 1967–69 x-radiation investigation (*2*). All of these receivers had been manufactured before the promulgation of the Public Health Service's regulation. Approximately 11 percent of the 104 color television sets resurveyed were again emitting x radiation above 0.5 mR/h at 5 cm from the surface of the television receiver (table 1). The readings ranged from 0.6 mR/h to less than 10 mR/h. Further investigations revealed that either the television set owner repaired his own television or an independent television serviceman serviced the television set without using a voltmeter. These sets were corrected by the television serviceman under the supervision of a radiation specialist of the Suffolk County Radiation Control Unit.

Table 1. Results of a followup color television receiver inspection[a]

Color television receiver (brand or manufacturer)	Number of television receivers with an exposure rate at 5 cm from the surface of the set of:			
	≤0.5 mR/h	>0.5–<1.0 mR/h	1.0–<10.0 mR/h	Total
Admiral	9	1	1	11
Clairtone	1	0	0	1
Curtis Mathis	1	0	0	1
Emerson	1	0	0	1
General Electric	7	2	0	9
Grants (Bradford)	1	1	0	2
Magnavox	5	1	0	6
Montgomery Ward Airline	1	0	0	1
Motorola	1	1	0	2
Philco	1	0	0	1
RCA	21	1	1	23
Sears/Japanese	2	0	0	2
Sylvania	1	0	0	1
Westinghouse	1	0	0	1
Zenith	39	2	1	42
Total	92	9	3	104

[a] As of December 31, 1970, 11.5 percent of television receivers were above the U.S. Public Health Standards.

To remedy the problem of recurring excessive radiation emission from those color television receivers manufactured before the effective date of the standard, the radiation specialist is collaborating, whenever possible, with the local independent television serviceman and the owner of the television receiver and through personal visits is educating them to the general causes of x-radiation emissions, the accepted methods of measuring high voltage outputs, and the accepted procedures for detecting the x-ray emissions.

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In summary, the survey of color television sets manufactured after the effective date of the Public Health Service standard shows improvement in the reduction of radiation emission. Those color television sets manufactured before the effective date of the standard that are being serviced by the factory-trained television servicemen reveal no levels of x-radiation emissions above natural background emissions.

Hopefully, with the cooperation of the independent television serviceman and the individual color television set owner, the x-radiation problem in color television receivers will be eliminated, and the television x-radiation inspection program in Suffolk County will then be phased out.

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SECTION I. MILK AND FOOD

Milk Surveillance, May 1971

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone, and many of the State Health Departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

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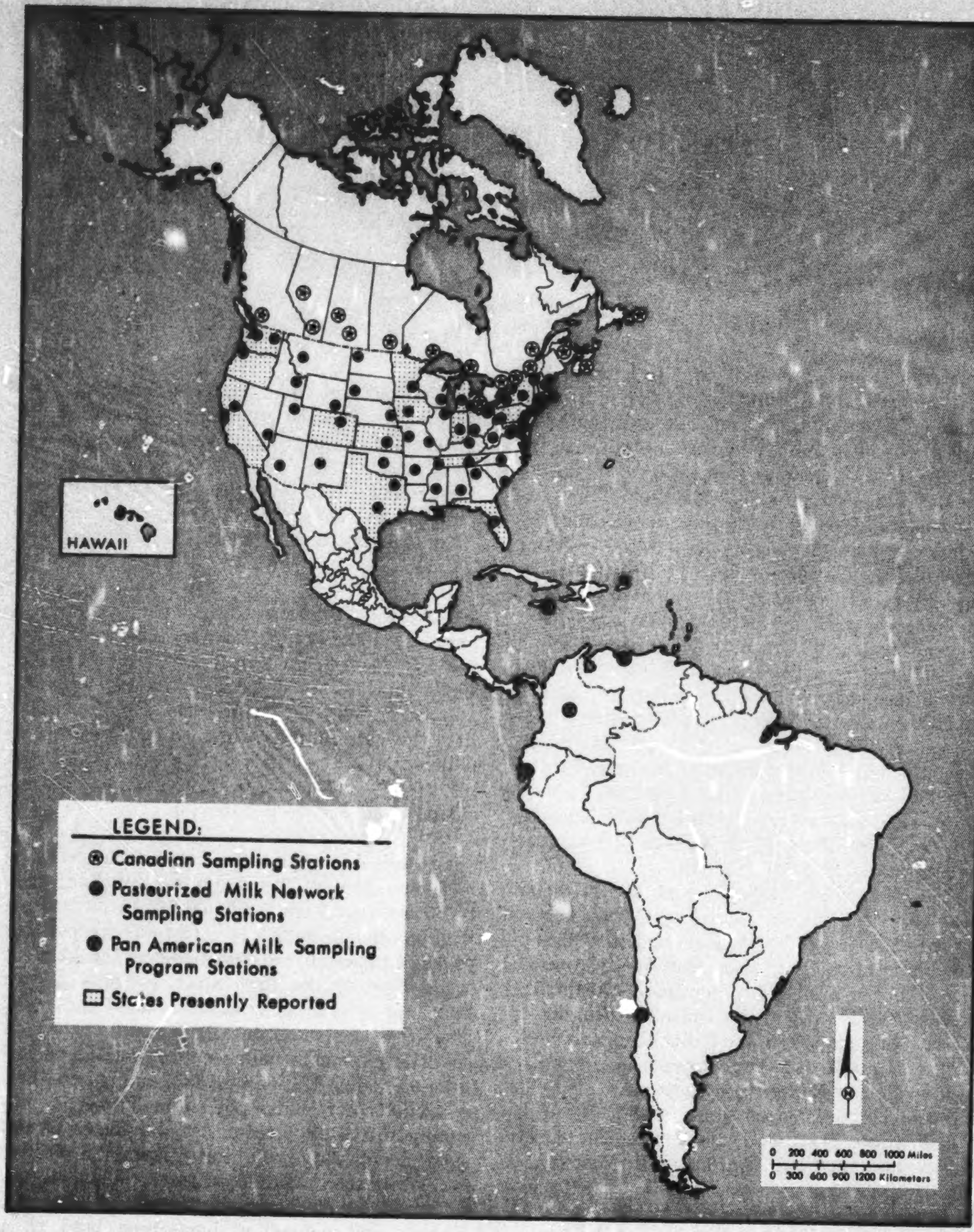
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
● Pan American Milk Sampling Program Stations
▨ States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

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metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during May–July 1970, with 28 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 (*5*). Of the 18 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 13 participated in the experiment.

The accuracy results of this experiment are shown in table 1. In general, considerable improvement is needed, especially in the accuracy measurements. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration		Number of laboratories in each category			
		Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Strontium 89:	High (258 pCi/liter)	7 (44%)	1 (6%)	8 (50%)	16
	Low (15 pCi/liter)	11 (69%)	3 (19%)	2 (12%)	16
Strontium-90:	Intermediate (79.4 pCi/liter)	13 (57%)	4 (17%)	6 (26%)	23
	Low (32.0 pCi/liter)	5 (25%)	4 (20%)	11 (55%)	20
Iodine-131:	High (507 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
	Low (49 pCi/liter)	16 (64%)	3 (12%)	6 (24%)	25
Cesium-137:	High (259 pCi/liter)	20 (74%)	3 (11%)	4 (1[illegible])	27
	Low (53 pCi/liter)	17 (66%)	5 (19%)	4 (15%)	26
Barium-140:	High (302 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
	Low (33 pCi/liter)	23 (92%)	0	2 (8%)	25

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

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The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports.*

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*7*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥ 50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥ 20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and*

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Table 2. Concentrations of radionuclides in milk for May 1971 and 12-month period, June 1970 through May 1971

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	NA	6	0	0	12	9
Alaska:	Palmer[c]	P	3	5	0	0	0	12
Ariz:	Phoenix[c]	P	NA	0	0	0	0	0
Ark:	Little Rock[c]	P	11	13	0	0	19	13
Calif:	Sacramento[c]	P	NA	2	0	0	0	0
	San Francisco[c]	P	NA	2	0	0	0	0
	Del Norte	P	20	16	0	0	29	11
	Fresno	P	2	2	0	0	2	1
	Humboldt	P	8	5	0	0	8	4
	Los Angeles	P	2	2	0	0	0	0
	Mendocino	P	16	5	0	0	15	5
	Sacramento	P	4	3	0	0	3	1
	San Diego	P	1	2	0	0	0	0
	Santa Clara	P	2	2	0	0	4	1
	Shasta	P	3	3	0	0	4	2
	Sonoma	P	5	3	0	0	4	2
Colo:	Denver[c]	P	NA	5	0	0	11	3
	West	R	(d)		NS	[e]0	NS	[e]0
	Northeast	R	(d)		[e]0(2)	[e]0	[e]0(2)	[e]0
	East	R	(d)		[e]0	[e]0	[e]0	[e]5
	Southeast	R	(d)		NS	NS	NS	NS
	South Central	R	(d)		NS	[e]0	NS	[e]0
	Southwest	R	(d)		[e]0	[e]0	0	[e]3
	Northwest	R	(d)		[e]0(2)	[e]0	0(2)	[e]0
Conn:	Hartford[c]	P	NA	7	0	0	14	13
	Central	P	6	7	0	0	27	17
Del:	Wilmington[c]	P	NA	10	0	0	0	8
D.C:	Washington[c]	P	NA	7	0	0	0	9
Fla:	Tampa[c]	P	4	5	0	0	40	48
	West	R	10	9	0	0	28	17
	North	R	5	9	0	0	30	26
	Northeast	R	6	6	0	0	32	35
	Central	R	5	6	0	0	65	49
	Tampa Bay area	P	6	6	0	0	45	50
	Southeast	R	7	7	0	1	74	81
Ga:	Atlanta[c]	P	NA	11	0	0	15	14
Hawaii:	Honolulu[c]	P	2	3	0	0	0	0
Idaho:	Idaho Falls[c]	P	5	5	0	0	16	9
Ill:	Chicago[c]	P	6	7	0	0	0	11
Ind:	Indianapolis[c]	P	NA	8	0	0	0	8
	Northeast	P	7	9	0	5	10	10
	Southeast	P	7	1	0	0	15	14
	Central	P	9	11	0	0	5	12
	Southwest	P	12	11	0	0	5	11
	Northwest	P	9	12	0	0	10	9
Iowa:	Des Moines[c]	P	6	6	0	0	0	3
	Iowa City	P	10	8	0(2)	0	13(2)	15
	Des Moines	P	8	8	0(4)	0	13(4)	12
	Spencer	P	5	5	0	0	16	9
	Fredericksburg	P	NS	NS	NS	NS	NS	NS
Kans:	Wichita[c]	P	NA	7	0	0	0	3
	Coffeyville	P	8	8	16	5	22	8
	Dodge City	P	8	8	0	0	0	2
	Falls City	R	7	12	11	5	0	8
	Hays	P	7	12	14	4	0	4
	Kansas City	P	10	8	0	5	11	13
	Topeka	P	11	10	13	3	39	11
	Wichita	P	9	12	18	2	22	6
Ky:	Louisville[c]	P	NA	10	0	0	0	3
La:	New Orleans[c]	P	14	14	0	0	19	19
Maine:	Portland[c]	P	NA	10	0	0	18	22
Md:	Baltimore[c]	P	NA	8	0	0	13	8
Mass:	Boston[c]	P	9	9	0	0	16	21
Mich:	Detroit[c]	P	NA	8	0	0	0	10
	Grand Rapids[c]	P	NA	9	0	0	16	15
	Bay City	P	NS	7	NS	[e]0	NS	13
	Charlevoix	P	NA	11	[e]0	[e]1	13	15
	Detroit	P	6	7	[e]0	[e]0	12	9
	Grand Rapids	P	6	9	[e]0	[e]0	13	9
	Lansing	P	NA	9	[e]0(2)	[e]0	13(2)	14
	Marquette	P	NA	11	[e]0	[e]0	22	23
	Monroe	P	4	6	[e]0	[e]0	0	4
	South Haven	R	4	7	[e]0(4)	[e]0	15(4)	7
Minn:	Minneapolis[c]	P	NA	10	0	0	15	14
	Bemidji	P	NS	8	NS	0	NS	20
	Mankato	P	6	5	0	0	16	11
	Rochester	P	8	7	0	0	0	12
	Duluth	P	17	15	0	0	24	29
	Worthington	P	5	4	0	0	11	0
	Minneapolis	P	13	11	0	0	18	19
	Fergus Falls	P	7	6	0	0	15	13
	Little Falls	P	16	13	0	0	20	35

See footnotes at end of table.

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Table 2. Concentration of radionuclides in milk for May 1971 and 12-month period June 1970 through May 1971—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
Miss:	Jackson[c]	P	NA	12	0	0	12	10
Mo:	Kansas City[c]	P	NA	8	0	0	0	3
	St. Louis[c]	P	NA	10	0	0	12	[e]
Mont:	Helena[c]	P	NA	5	0	0	15	10
Nebr:	Omaha[c]	P	NA	5	0	0	17	2
Nev:	Las Vegas[c]	P	NA	2	0	0	0	0
N.H:	Manchester[c]	P	NA	10	0	0	19	22
N.J:	Trenton[c]	P	NA	9	0	0	0	11
N. Mex:	Albuquerque[c]	P	NA	3	0	0	0	0
N.Y:	Buffalo[c]	P	6	7	0	0	0	12
	New York City[c]	P	NA	10	0	0	19	19
	Syracuse[c]	P	NA	7	0	0	13	11
	Albany	P	[e]0(4)	7	0(4)	0	[e]6(4)	[e]0
	Massena	P	[e]0(2)	8	0(2)	0	21(2)	24
	Newburg	P	6(4)	7	0(4)	0	[e]0(4)	[e]0
	New York City	P	9	10	0	0	[e]0	[e]0
	Syracuse	P	3(2)	4	0(2)	0	[e]0(2)	[e]0
N.C:	Charlotte[c]	P	NA	11	0	0	13	12
N. Dak:	Minot[c]	P	NA	8	0	0	14	10
Ohio:	Cincinnati[c]	P	NA	7	0	0	0	2
	Cleveland[c]	P	NA	8	0	0	13	13
Okla:	Oklahoma City[c]	P	NA	6	0	0	17	7
Oreg:	Portland[c]	P	6	5	0	0	0	3
	Baker	P	3	3	[e]0	[e]0	[e]0	9
	Coos Bay	P	7	6	[e]0	[e]0	16	12
	Eugene	P	3	4	[e]0	[e]0	[e]0	1
	Medford	P	0	2	[e]0	[e]0	[e]0	9
	Portland composite	P	2	5	[e]0	[e]0	10	6
	Portland local	P	3	4	[e]0	[e]0	12	9
	Redmond	P	2	3	[e]0	[e]0	[e]0	2
	Tillamook	P	4	6	[e]0	[e]0	19	15
Pa:	Philadelphia[c]	P	NA	9	0	0	13	8
	Pittsburgh[c]	P	NA	11	0	0	0	15
	Dauphin	P	0	7	0	0	8	14
	Erie	P	6	11	0	0	16	25
	Philadelphia	P	8	9	0	0	13	16
	Pittsburgh	P	13	13	0	0	14	22
R.I:	Providence[c]	P	NA	9	0	0	14	19
S.C:	Charleston[c]	P	10	9	0	1	15	15
S. Dak:	Rapid City[c]	P	NA	7	0	0	0	5
Tenn:	Chattanooga[c]	P	NA	9	0	0	14	9
	Memphis[c]	P	NA	8	0	0	11	8
	Chattanooga	P	10	9	0	0	10	15
	Clinton	P	9	10	0(2)	0	12(2)	16
	Fayetteville	P	15	11	0	0	12	15
	Knoxville	P	8	6	0(2)	0	7(2)	13
	Nashville	P	7	6	0	0	0	11
Tex:	Austin[c]	P	NA	2	0	0	0	2
	Dallas[c]	P	NA	6	0	0	11	5
	Amarillo	R	NS		NS		NS	
	Corpus Christi	R	NS		NS		NS	
	El Paso	R	NS		NS		NS	
	Forth Worth	R	NS		NS		NS	
	Harlingen	R	NS		NS		NS	
	Houston	R	NS		NS		NS	
	Lubbock	R	NS		NS		NS	
	Midland	R	NS		NS		NS	
	San Antonio	R	NS		NS		NS	
	Texarkana	R	NS		NS		NS	
	Tyler	R	NS		NS		NS	
	Uvalde	R	NS		NS		NS	
	Wichita Falls	R	NS		NS		NS	
Utah:	Salt Lake City[c]	P	NA	4	0	0	15	14
Vt:	Burlington[c]	P	NA	8	0	0	19	15
Va:	Norfolk[c]	P	NA	9	0	0	0	7
Wash:	Seattle[c]	P	NA	5	0	0	0	3
	Spokane[c]	P	NA	5	0	0	0	1
	Benton County	R	0	1	0	0	0	2
	Franklin County	R	NS	3	NS	0	NS	3
	Sandpoint, Idaho	R	9	11	0	0	11	21
	Skagit County	R	9	7	0	0	10	10
W. Va:	Charleston[c]	P	NA	8	0	0	12	7
Wisc:	Milwaukee[c]	P	NA	6	0	0	11	13
Wyo:	Laramie[c]	P	NA	5	0	0	0	1
CANADA:								
Alberta:	Calgary	P	NA		(d)		22	18
	Edmonton	P	NA		(d)		18	22
British Columbia:	Vancouver	P	NA		(d)		22	23
Manitoba:	Winnipeg	P	NA		(d)		23	24

See footnotes at end of table.

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Table 2. Concentration of radionuclides in milk for May 1970 and 12-month period June 1970 through May 1971—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA: Continued								
New Brunswick:	Fredericton	P	NA		(d)		27	25
Newfoundland:	St. John's	P	NA		(d)		21	31
Nova Scotia:	Halifax	P	NA		(d)		19	21
Ontario:	Ottawa	P	NA		(d)		16	15
	Sault Ste. Marie	P	NA		(d)		39	34
	Thunder Bay	P	NA		(d)		24	25
	Toronto	P	NA		(d)		16	11
	Windsor	P	NA		(d)		13	11
Quebec:	Montreal	P	NA		(d)		18	19
	Quebec	P	NA		(d)		32	30
Saskatchewan:	Regina	P	NA		(d)		18	14
	Saskatoon	P	NA		(d)		21	16
CENTRAL AND SOUTH AMERICA:								
Colombia:	Bogota	P	0	1	0	0	10	1
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Kingston	P	3	5	0	0	30	74
Venezuela:	Caracas	P	NS	1	NS	0	NS	0
Canal Zone:	Cristobal[c]	P	NS	2	NS	0	NS	10
Puerto Rico:	San Juan[c]	P	NA	4	0	0	13	10
PMN network average[f]			7	7	0	0	9	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclides concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

Reports in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

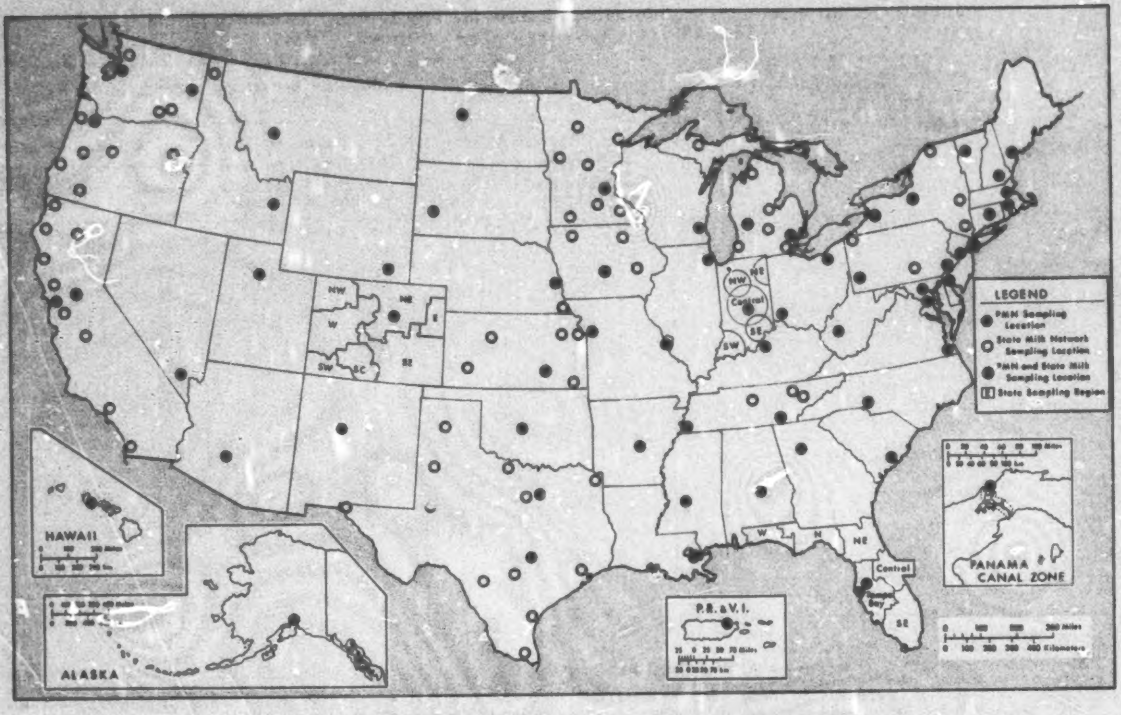
LEGEND
PMN Sampling Location
State Milk Network Sampling Location
PMN and State Milk Sampling Location
State Sampling Region
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE
NW
NE
W
SW
SC
SE
E
Central

Figure 2. State and PMN milk sampling stations in the United States

Discussion of current data

In table 2, surveillance results are given for strontium-90, iodine-131, and cesium-137 for May 1971 and the 12-month period, June 1970 to May 1971. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for May 1971 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89 and barium-140 were detected.

Iodine-131 results are included in table 2, even though they were generally below practical reporting levels. Because of the lower guide levels established by the Federal Radiation Council, levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Table 3. Strontium-89 and barium-140 in milk May 1971

Sampling location		Radionuclide concentration (pCi/liter)	
		Strontium-89	Barium-140
Calif:	Del Norte (State)	26	
	Humboldt (State)	11	
	Mendocino (State)	24	
	Sacramento (State)	6	
Kans:	Coffeyville (State)	10	
	Dodge City (State)		11
	Hays (State)		17
	Topeka (State)		18
Oreg:	Portland (PMN)	6	
Tenn:	Chattanooga (State)	6	
	Clinton (State)	7	
	Knoxville (State)	15	
	Nashville (State)	11	

Strontium-90 monthly averages ranged from 0 to 20 pCi/liter in the United States for May 1971, and the highest 12-month average was 16 pCi/liter (Del Norte, Calif.) representing 8.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 74 pCi/liter in the United States for May 1971, and the highest 12-month average was 81 pCi/liter (Southeast Florida), representing 2.8 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica. Iodine-131 results for individual samples were all below the practical reporting level, with the exception of Kansas, Coffeyville (State), 16 pCi/liter, Falls City (State) 11 pCi/liter, Hays (State) 14 pCi/liter, Topeka, (State) 13 pCi/liter, and Wichita (State) 18 pCi/liter.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiological Health Section
Division of Occupational and
Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational
Health Section
Department of Health and
Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of
Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of
Social and Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January–June 1970	November 1970
Carbon-14 in Total Diet and Milk	July–December 1970	May 1971
Connecticut Standard Diet	July–December 1969	December 1970
Institutional Diet Samples	October–December 1970 and Annual Summary 1970	May 1971
Strontium-90 in Tri-City Diets	January–December 1969	June 1970

1. Radionuclides in Institutional Diet Samples, January–March 1971

Environmental Protection Agency and *Food and Drug Administration*

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. The program is administered by the Office of Radiation Programs, Environmental Protection Agency with the assistance of the Office of Food Sanitation, Food and Drug Administration (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. At the present time, 25 institutions, distributed geographically as shown in figure 1, are being sampled. Previous results showed that the daily dietary intakes of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1, 2*). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intake of children.

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week, (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period and is then packed in dry ice and shipped by air express to either the Western Environmental Research Laboratory, Las Vegas, Nev; the Eastern Environmental Radiation Laboratory, Montgomery, Ala; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed de-

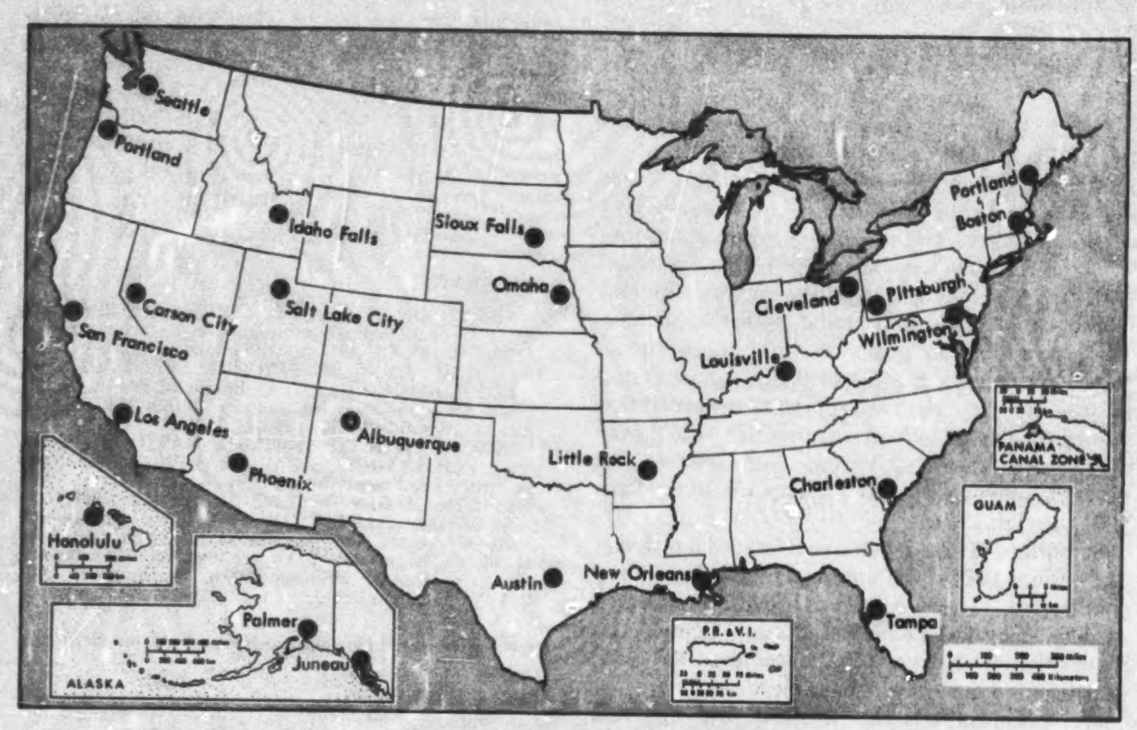
Seattle
Portland
Idaho Falls
Sioux Falls
Omaha
Carson City
Salt Lake City
San Francisco
Los Angeles
Albuquerque
Phoenix
Little Rock
Louisville
Cleveland
Pittsburgh
Wilmington
Portland
Boston
Charleston
New Orleans
Austin
Tampa
Honolulu
Palmer
Juneau
ALASKA
PANAMA CANAL ZONE
GUAM
P.R. & V.I.

Figure 1. Institutional diet sampling locations as of January–March 1971

Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children January–March 1971

Location of Institution		Month (1971)	Total weight (kg/day)	Calcium		Potassium		Strontium-90		Cesium-137	
				(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska:	Juneau	Jan	1.24	0.5	0.6	1.0	1.2	5	6	0	0
	Palmer	Jan	1.69	.5	.8	1.6	2.7	2	4	0	0
Ariz:	Phoenix	Jan	1.76	.3	.6	1.5	2.7	3	5	0	0
Ark:	Little Rock	Jan	1.27	.6	.8	1.7	2.2	7	9	0	0
Calif:	Los Angeles	Jan[a]	1.80	.4	.7	1.1	1.7	5	8	0	0
	San Francisco	Jan	1.57	.8	1.2	1.6	2.6	3	5	0	0
Del:	Wilmington	Jan	2.07	.6	1.3	1.6	3.2	6	13	0	0
Fla:	Tampa	Jan[a]	1.85	.5	.9	1.3	2.4	3	6	21	39
Hawaii:	Honolulu	Jan	2.13	.5	1.1	1.3	2.7	2	5	18	38
Ky:	Louisville	Jan	2.65	1.0	2.7	1.3	3.4	11	28	0	0
La:	New Orleans	Jan[a]	1.84	.7	1.2	1.5	2.8	8	15	15	28
Maine:	Portland	Jan	1.75	.8	1.4	1.6	2.8	11	19	16	28
Mass:	Boston	Jan	2.18	.6	1.2	1.3	2.8	7	15	14	31
Nebr:	Omaha	Jan[a]	1.95	.8	1.6	1.6	3.2	7	13	12	23
Nev:	Carson City	Jan	1.52	.6	1.0	1.4	2.1	4	5	0	0
N. Mex:	Albuquerque	Jan	2.44	.4	1.0	.9	2.3	0	0	0	0
Ohio:	Cleveland	Feb[a]	1.68	.7	1.1	1.5	2.6	7	11	0	0
Oreg:	Portland	Jan[a]	1.71	.5	.9	2.2	3.8	3	5	0	0
Pa:	Pittsburgh	Jan	2.23	.5	1.2	1.2	2.6	6	12	0	0
S.C:	Charleston	Jan[a]	1.91	.5	1.1	1.4	2.6	7	12	14	27
S. Dak:	Sioux Falls	Jan	1.14	.6	.7	1.4	1.6	6	7	0	0
Tex:	Austin	Jan[a]	1.74	.7	1.3	1.4	2.5	4	6	0	0
Utah:	Salt Lake City	Feb	1.99	.5	1.0	1.1	2.2	2	5	0	0
Wash:	Seattle	Jan[a]	1.63	.7	1.2	1.7	2.8	7	11	13	21
Institutional average			1.83	0.6	1.2	1.4	2.6	5	10	6	11

[a] Food samples were collected from two or more children who were not between the ages of 9 and 12.
Note: Strontium-89, iodine-131, and barium-140 were not detected at any station during this period.

scription of sampling and analytical procedures was presented earlier (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from all stations for January–March 1971. The stable elements, calcium and potassium, are reported in g/kg of diet. The radionuclide concentrations of these samples reported in pCi/kg of diet are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.83 kg/day compared to the network average of 1.87 kg/day observed from 1961 through 1969.

Strontium-90 dietary intake averaged 5 pCi/day and cesium-137 intake averaged 6 pCi/day during this period. These results fall within Range I as defined by the Federal Radiation Council (*4*). Strontium-89, barium-140, and iodine-131 concentrations were below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level have been reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2-standard-deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Strontium-89	5 pCi/kg
Strontium-90	2 pCi/kg
Iodine-131	10 pCi/kg
Cesium-137	10 pCi/kg
Barium-140	10 pCi/kg

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Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1970	January 1971
July–September 1970	February 1971
October–December 1970	May 1971

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiological Health Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	July–December 1968	August 1970
Interstate Carrier Drinking Water	1970	July 1971
Kansas	January–December 1969	September 1970
Minnesota	July–December 1969	May 1971
North Carolina	January-December 1967	May 1969
New York	January–June 1969	June 1970
Radiostrontium in Tap Water, *HASL*	January–December 1969	July 1970
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	January–March 1971	July 1971
Washington	July 1968–June 1969	February 1971

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, January 1971

Office of Water Programs
Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the Environmental Protection Agency, Office of Water Programs. Regional Offices of the Environmental Protection Agency are responsible for the collection of samples and entering of the analytical findings into STORET, the Office of Water Programs' computerized data storage and retrieval system. Radioactivity analyses are performed in the centralized radioactivity laboratories of the Office of Water Programs (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for the month of October 1968 (April 1969 issue). With this publication of data for January 1971, it is intended to reinitiate this activity. The unpublished data for the time interval of November 1968 through December 1970 will be the the subject of a future summary article.

Table 1 presents the gross alpha and beta results for samples collected from 12 rivers during January 1971. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of "Standard Methods for the Examination of Water and Wastewater" (*1*). Results are reported for the date of counting and are not corrected by extrapolation to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*) and is calculated to be <0.2 pCi/liter for gross alpha and <1 pCi/liter for gross beta measurements.

Table 1. Gross radioactivity in U.S. surface waters, January 1971

River and station	Number of grab samples[a]	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Clinch River:					
Kingston, Tenn.	4	<0.2 (< .2, <0.2)	<0.2 (< .2, < .2)	<1 (<1, 1)	10 (7, 14)
Great Miami:					
Elizabethtown, Ohio	1	1	2	1	11
American Material Bridge, Ohio	1	< .2	2	3	8
Fairfield, Ohio	1	1	2	1	11
Sellars Road Bridge, Ohio	1	< .2	2	1	7
Kentucky River:					
Lock and Dam No. 1	1	2	< .2	11	8
Licking River:					
Covington, Ky.	1	2	< .2	8	8
Little Miami River:					
Cincinnati, Ohio	1	< .2	2	2	10
Mississippi River:					
Burlington, Iowa	1	< .2	1	1	7
Ohio River:					
Markland Dam	1	< .2	2	5	5
Cincinnati, Ohio	4	<1 (< .2, 1)	< .2	6 (2, 11)	4 (3, 5)
Portsmouth, Ohio	1	3	2	10	4
Ironton, Ohio	1	< .2	1	2	3
Roanoke River:					
John Kerr Dam, Va.	3	< .2 (< .2, < .2)	< .2 (< .2, < .2)	<1 (<1, 1)	4 (4, 4)
St. Lawrence River:					
Massena, N.Y.	3	< .2 (< .2, < .2)	< .2 (< .2, 1)	<1 (<1, 1)	6 (6, 6)
St. Mary River:					
Sault Ste. Marie, Mich.	1	< .2	< .2	<1	2
Susquehanna River:					
Holtwood, Pa.	1	< .2	< .2	2	3
Whitewater River:					
State Line (Ohio-Ind.)	1	< .2	4	<1	5

[a] Where more than one sample is analyzed, the minimum and maximum values are in parentheses.

REFERENCES

(1) AMERICAN PUBLIC HEALTH ASSOCIATION; AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th Edition, New York, N.Y. (1971).

(2) U.S. DEPARTMENT OF COMMERCE. Radioactivity, recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

Radioactivity in New York Surface Water July-December 1969 and January-June 1970

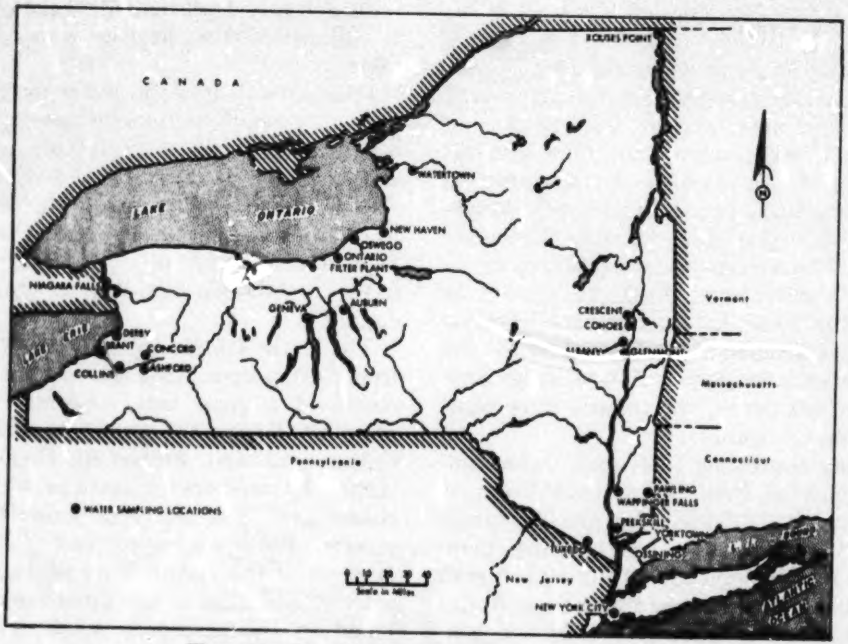
Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

In 1955, the New York State Department of Health began a program to determine the amount of radioactivity in water used for public consumption. On July 1, 1971 this program was transferred to the newly formed New York State Department of Environmental Conservation. Radioactivity in water may arise from any one or a combination of the following sources: the natural mineral content of water (background), atmospheric fallout, or nuclear industry operations.

Analytical procedures

A measured quantity of water, usually 500 ml, is evaporated and the residue is analyzed for its gross beta component in an end-window, gas-flow proportional counter.

Strontium and alkaline earths are precipitated as carbonates from a 500-ml sample. Iron and rare earths are removed by hydroxide scavenging, while barium is precipitated as a chromate. Strontium is finally precipitated as a sulphate from a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WATERTOWN
NEW HAVEN
OSWEGO
ONTARIO FILTER PLANT
NIAGARA FALLS
GENEVA
AUBURN
LAKE ERIE
DERBY
BRANT
CONCORD
COLLINS
CRESCENT
COHOES
ALBANY
Vermont
Massachusetts
Connecticut
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PAWLING
WAPPINGER FALLS
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YORKTOWN
OSSINING
TUXEDO
New Jersey
NEW YORK CITY
ATLANTIC OCEAN
N
● WATER SAMPLING LOCATIONS
0 10 20 30 40
Scale in Miles

Figure 1. New York water sampling locations

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pH controlled EDTA solution. Calcium and yttrium remain in solution as EDTA complexes (*1–2*).

Strontium-90 is determined by yttrium-90 ingrowth counting of the final precipitate at less than 6 hours after precipitation and again at greater than 50 hours using a low background (less than 1 cpm) gas-flow, proportional beta-particle counter. Strontium-89 is estimated by taking the difference between the total strontium and the strontium-90 radioactivity.

Chemical recovery is between 70 and 75 percent and results in a minimum detectable radioactivity of 3 pCi/liter ± 100 percent at the 95-percent confidence level.

Tritium in water is determined by liquid scintillation counting of 3 ml of distilled sample in 17 ml of scintillator solution. The scintillator solution consists of 4 g PPO, 0.25 g naphthalene dissolved in 1 liter of dioxane. The sample is counted twice for a total of 100 minutes using either a Packard Tri-Carb model 3315 or a Beckman LS 200B liquid scintillation spectrometer. Minimum sensitivities at the 95-percent confidence level ± 100 percent are 1,000 pCi/liter for the Tri-Carb and 500 pCi/liter for the Beckman.

Discussions and results

Radioactivity levels in water for July-December 1969 continued to remain low throughout the State with the exception of Buttermilk and Cattaraugus Creeks downstream from Nuclear Fuel Services. The gross beta and strontium-90 levels in Cattaraugus Creek for October–December were higher than for the July–September 1969 period. The average concentration of strontium-90 in Cattaraugus Creek at Springville Dam was 98 pCi/liter for the October–December 1969 period as compared to 25 pCi/liter for the July–September 1969 period. A new water sampling station was added, the Ontario filter plant in Wayne County (figure 1).

During July–September 1969, some water samples were collected from Cattaraugus Creek at Felton Bridge, site 032, instead of the Springville Dam, site 042, due to the annual cleaning operation to flush out silt from behind the dam. A grab sample upsteam from the dam at Felton Bridge was collected on September 17, 1969 and contained 915 pCi/liter gross beta radioactivity. This is higher than the 600 pCi/liter considered to be the allowable limit for gross beta radioactivity.

Beta and gamma radiation from the isotope ruthenium-106 has started to appear in significant concentrations in the water courses below Nuclear Fuel Services resulting in increased gross beta levels. This increase apparently results from the processing of spent fuel that had a shorter storage period than fuels previously processed. Ruthenium-106 has a good fission yield and will decay in spent fuel with a half-life of 1 year, so that the longer spent fuel is stored before processing, the less the ruthenium-106 activity. The amount of ruthenium-106 in spent fuel stored for 5 years will be lower by a factor of 16 than spent fuel stored for 1 year. The maximum concentration allowed for ruthenium-106 in drinking water is 10.0 nCi/liter and the most important human exposure is the exposure to the lower large intestine. Ruthenium-106 does not concentrate in any particular organ of the human body nor has it been found to significantly reconcentrate in edible fish, milk, or other food pathways for human exposure.

The number of samples and the quarterly average, maximum, and minimum gross beta-particle concentrations in New York surface water for July–December 1969 are given in table 1. Strontium-90 in surface water is shown in table 2.

Radioactivity levels in water for the January–June 1970 period continue to remain low throughout the State with the exception of Buttermilk and Cattaraugus Creeks, downstream of Nuclear Fuel Services, Incorporated. Two daily samples from Site 042 (Cattaraugus Creek at Springville Dam) were over 600 pCi/liter which is considered to be the allowable AEC limit for gross beta radioactivity.

The water sample collected on May 26, 1970 from Cattaraugus Creek downstream at Gowanda contained a gross beta concentration of 1,166 pCi/liter. During this period, the stream beds in Cattaraugus and Buttermilk Creeks were disturbed by bulldozer operations which probably resuspended clay and silts which flowed downstream. Both suspended and dissolved solids portions of the sample were analyzed for radioactivity and most of the gross radioactivity was found in the suspended solids portion of the sample.

Table 1. Gross beta radioactivity in New York raw surface water, July–December 1969[a]

Location	Gross beta radioactivity (pCi/liter)							
	July–September 1969				October–December 1969			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	3	2	3	2	2	3	3	2
Ashford (Buttermilk Creek at Fox Valley Road)	2	3	5	ND	3	4	5	4
(Buttermilk Creek at Thomas Corners)[b]	14	2,587	5,446	173	13	2,135	5,060	379
(Cattaraugus Creek at Bigelow Bridge)	3	2	3	ND	3	4	6	2
(Cattaraugus Creek at Felton Bridge)	10	342	915	132	8	322	593	206
Brant (Cattaraugus Creek)	14	136	235	85	11	121	225	39
Collins (Cattaraugus Creek)	14	179	419	82	11	168	261	109
Concord (Cattaraugus Creek)	58	279	506	143	12	351	585	167
(Cattaraugus Creek—Site 042)	NS	NS	NS	NS	55	329	926	71
Crescent (Crescent Dam)	10	4	5	3	11	3	5	2
Geneva (Seneca Lake)	2	4	4	4	3	5	8	4
Glenmont (Hudson River)	8	4	5	3	10	4	10	3
New Haven (Lake Ontario)	3	4	5	4	3	4	4	3
New York City	NA	NA	NA	NA	5	2	4	ND
Niagara Falls (West Branch, Niagara River)	2	4	4	4	3	4	5	3
Ontario Filter Plant	3	5	6	4	2	4	4	3
Ossining (Indian Brook Reservoir)	3	4	7	ND	3	4	7	ND
(Sing Sing) (Hudson River)	12	34	60	12	11	35	71	14
Oswego	3	4	5	3	2	4	4	3
Pawling (Pond at United Nuclear)	4	4	5	3	5	3	4	2
Peekskill (Camp Field water supply)	3	ND	ND	ND	3	4	13	ND
(Hudson River)	12	13	30	ND	11	14	32	ND
Tuxedo (Indian Kill)	3	7	11	5	3	4	6	3
Watertown (Black River)	4	4	5	3	3	3	3	3
Yorktown (Croton Reservoir)	3	4	4	3	3	4	5	3

[a] Excluding tritium.
[b] This station is on the Nuclear Fuels Services reprocessing plant site.
NA, no analysis.
ND, nondetectable.
NS, no sample.

Table 2. Strontium-90 concentration in New York surface waters, July–December 1969

Location	Radionuclide concentration (pCi/liter)							
	July–September 1969				October–December 1970			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Ashford (Buttermilk Creek at Thomas Corners)[a]	14	308	1,111	80	13	703	1,658	182
(Cattaraugus Creek at Felton Bridge)	3	135	194	97	1	72	—	—
(Cattaraugus Creek at Bigelow Bridge)	3	ND	ND	ND	3	ND	ND	ND
(Buttermilk Creek at Fox Valley Road)	3	ND	ND	ND	3	ND	ND	ND
Brant (Cattaraugus Creek)	11	14	32	ND	12	36	62	21
Collins (Cattaraugus Creek)	13	14	27	ND	12	43	75	24
Concord (Springville Power Dam on Cattaraugus Creek)	12	25	55	10	12	98	208	51
(Springville Dam—Site 042)[b]	NS	NS	NS	NS	5	114	224	53
Hudson River at Standard Brands	10	ND	ND	ND	12	ND	ND	ND
Hudson River at Sing Sing	10	ND	ND	ND	12	ND	ND	ND

[a] This station is in the Nuclear Fuels Services reprocessing plant site.
[b] Daily continuous sample taken.
ND, nondetectable.
NS, no sample.

Table 3. Radioactivity in an algae sample collected July 9, 1970, Croton Reservoir

Radionuclide	Concentration (pCi/kg wet weight)
Ruthenium-rhodium-106	2,916
Cesium-137	479
Zirconium-niobium-95	1,484
Cobalt-60	nondetectable

Table 4. Gross beta radioactivity in water samples Croton Reservoir

Date (1970)	Concentration (pCi/liter)
April 16	5
May 18	80
June 16	7
July 2	4
July 15	4

A grab water sample collected on May 18, 1970 from Croton Reservoir at Taconic showed a gross beta concentration of 80 pCi/liter. An isotopic gamma analysis was made on this sample, and ruthenium-106 was nondetectable. Zirconium-95 was found in a concentration of 53 pCi/liter. An algae sample was collected July 9, 1970 at the same sampling point, and the results are shown in table 3. Gross beta results of grab water samples taken from this sampling point, around the period of the relatively high result, are given in table 4.

It was concluded that the water sample with the high result was collected too close to the shoreline in shallow water and some algae was included in the water sample. The radioactivity found in the water sample and in the algae sample appears to have originated from fallout associated with atmospheric weapons testing. This sampling point has been changed to deeper water in the Croton Reservoir in order to obtain a more representative water sample in the future.

Table 5. Gross beta radioactivity in New York raw surface water, January–June 1970[a]

Location	Gross beta radioactivity (pCi/liter)							
	January–March 1970				April–June 1970			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	3	2	2	2	3	2	3	2
Ashford (Buttermilk Creek at Fox Valley Road)[a]	3	13	31	2	3	4	5	3
(Buttermilk Creek at Thomas Corners)[b]	13	1,940	3,576	530	13	1,183	2,564	156
(Cattaraugus Creek at Bigelow Bridge)	3	[illegible]	19	2	3	4	7	3
Brant (Cattaraugus Creek)	7	86	125	55	13	68	139	22
Collins (Cattaraugus Creek)	13	108	161	33	13	154	1,196	20
Concord (Cattaraugus Creek)	13	247	367	142	13	155	246	61
Geneva (Seneca Lake)	2	4	4	3	3	4	5	4
Glenmont (Hudson River)	13	4	7	2	13	4	5	3
New Haven (Lake Ontario)	4	4	4	3	2	4	5	4
New York City	7	3	3	2	7	4	5	2
Niagara Falls (West Branch Niagara River)	2	4	4	4	3	3	4	3
Ossining (Indian Brook Reservoir)	3	4	5	4	3	7	13	3
(Sing Sing) (Hudson River)	16	21	48	ND	13	17	36	4
Oswego	3	4	4	3	3	4	4	4
Pawling (Pond at United Nuclear)	3	2	2	2	5	4	5	3
Peekskill (Camp Field Water Supply)	3	4	9	ND	3	6	10	4
(Hudson River)	14	7	19	ND	13	9	20	2
Tuxedo (Indian Kill)	3	5	5	4	3	5	6	5
Watertown (Black River)	3	3	4	3	3	4	5	3
Yorktown (Croton Reservoir)	3	5	6	4	3	31	80	5

[a] Excluding tritium.
[b] This station is on the Nuclear Fuels Services reprocessing plant site.
ND, nondetectable.

Table 6. Strontium-90 concentration in New York surface waters, January–June 1970

Location	Radionuclide concentration (pCi/liter)							
	January–March 1970				April–June 1970			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Ashford (Buttermilk Creek at Thomas Corners)[a]	11	800	1,624	311	14	459	1,351	88
(Cattaraugus Creek at Bigelow Bridge)	3	ND	ND	ND	3	ND	ND	ND
(Buttermilk Creek at Fox Valley Road)	3	ND	ND	ND	3	ND	ND	ND
Brant (Cattaraugus Creek at Irving)	7	39	85	19	14	25	49	ND
Collins (Cattaraugus Creek at Gowanda)	11	47	94	18	14	30	73	8
Concord (Springville Power Dam on Cattaraugus Creek)	12	89	148	54	13	48	97	ND
(Springville Dam—Site 042)[b]	2	114	139	89	2	62	92	32
Derby (Sturgeon Point Station)	1	ND	ND	ND	3	ND	4	ND
Peekskill (Hudson River at Standard Brands)	12	ND	ND	ND	14	ND	ND	ND
(Hudson River—Sing Sing)	12	ND	ND	ND	15	ND	ND	ND

[a] This station is in the Nuclear Fuels Services reprocessing plant site.
[b] Daily continuous sample taken.
ND, nondetectable.

Gross beta-particle concentrations for the January–June 1970 period are given in table 5; strontium-90 concentrations are given in table 6.

Tritium concentration values for July 1969–June 1970 are given in tables 7 and 8. Tritium, the radioactive isotope of hydrogen, a very low energy beta-particle emitter, is released to the water courses during the reprocessing of nuclear fuel. The tritium concentrations in Cattaraugus and Buttermilk Creeks reflected contributions to the streams from the Nuclear Fuels Services reprocessing plant.

REFERENCES

(1) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Improved determination of strontium-90 in milk by ion-exchange method. Anal Chem 33:1306–1308 (September 1961).

(2) WELFORD, G. and D. SUTTON. Paper presented at the American Chemical Society meeting in New York City, September 1960.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1969	June 1970

Table 7. Tritium concentrations of New York surface waters, July–December 1969

Location	Concentration (nCi/liter)							
	July–September 1969				October–December 1969			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	3	ND	ND	ND	2	1.7	2.3	1.1
Ashford (Buttermilk Creek at Fox Valley Road)	2	ND	ND	ND	3	ND	ND	ND
(Buttermilk Creek at Thomas Corners)[a]	14	117.8	211.9	8.1	13	147.8	406.9	6.9
(Cattaraugus Creek at Bigelow Bridge)	3	ND	ND	ND	3	ND	ND	ND
(Cattaraugus Creek at Felton Bridge)	11	10.1	30.1	4.0	7	7.0	8.5	4.7
Brant (Cattaraugus Creek)	14	8.6	21.9	3.9	11	10.2	29.2	2.1
Collins (Cattaraugus Creek)	14	10.6	30.8	3.8	11	12.0	35.3	ND
Concord (Springville Power Dam on Cattaraugus Creek)	58	14.8	36.6	6.1	12	27.6	70.0	5.8
(Springville Dam-Site 042)[b]	NS	NS	NS	NS	55	26.5	96.6	2.6
Crescent (Crescent Dam)	11	ND	1.3	ND	10	ND	2.8	ND

[a] This station is on the Nuclear Fuels Services reprocessing plant site.
[b] Daily continuous sample.
ND, nondetectable.
NS, no sample.

Table 8. Tritium concentration of New York surface waters, January–June 1970

Location	Concentration (nCi/liter)							
	January–March 1970				April–June 1970			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	3	ND	1.4	ND	3	ND	ND	ND
(Colonie Filtration Plant)	4	ND	2.5	ND	14	1.1	6.3	ND
Ashford (Buttermilk Creek at Fox Valley Road)	3	ND	ND	ND	3	ND	1.7	ND
(Buttermilk Creek at Thomas Corners)[a]	13	179.6	430.6	17.0	13	243.0	802.8	2.3
(Cattaraugus Creek at Bigelow Bridge)	3	ND	1.7	ND	3	ND	2.1	ND
Brant (Cattaraugus Creek)	7	10.5	16.3	2.4	13	10.6	25.7	ND
Collins (Cattaraugus Creek)	13	11.8	26.1	2.4	13	10.0	27.6	ND
Concord (Springville Power Dam on Cattaraugus Creek)	13	22.0	44.3	5.3	13	18.6	39.6	ND
(Springville Dam-Site 042)[b]	62	22.9	98.6	1.9	62	18.0	54.4	ND
Crescent (Crescent Dam)	5	ND	1.2	ND	NS	NS	NS	NS
Derby (Sturgeon Point Station)	NS	NS	NS	NS	3	ND	1.8	ND
Oswego (City Hall Tap)	NS	NS	NS	NS	3	ND	1.5	ND
New Haven (Demster Peach Road)	NS	NS	NS	NS	3	ND	ND	ND
Rhinecliff (Hudson River)	NS	NS	NS	NS	13	ND	2.9	ND
Wappinger (Hudson River)	NS	NS	NS	NS	13	ND	2.9	ND

[a] This station is on the Nuclear Fuels Services reprocessing plant site.
[b] Daily continuous sample taken.
ND, nondetectable.
NS, no sample.

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports.*

Network	Period	Issue
Fallout in the United States and other Areas, *HASL*	July–December 1968 and January–December 1969	January 1971
Plutonium in Airborne Particulates and Precipitation	July–December 1970	June 1971
Surface Air Sampling Program, 80th Meridian Network, *HASL*	January–December 1968	April 1971

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1. Radiation Alert Network
May 1971

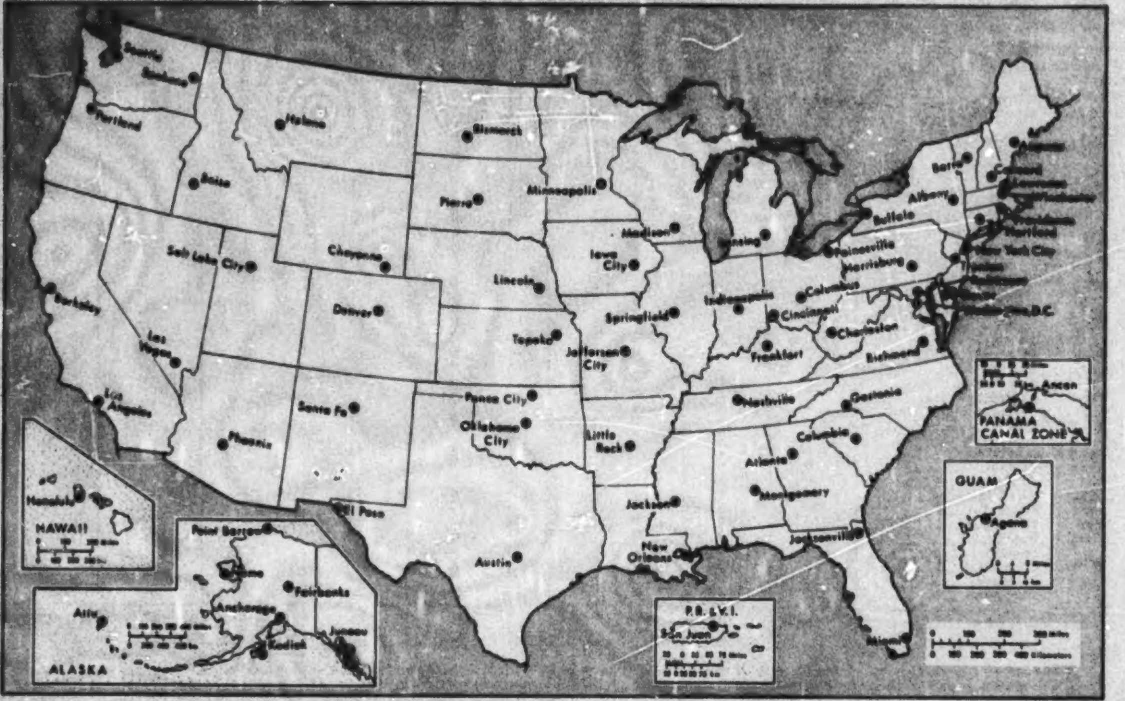
Office of Air Programs
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State Health Department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone, depending on levels found. A compilation of the daily field estimates is available upon request from the Data Acquisition and Analysis Branch, Division of Air Quality and Emission Data, EPA, Durham, N.C. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during May 1971.

All field estimates reported were within normal limits for the reporting station.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Los Angeles
Santa Fe
Ponca City
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Phoenix
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Nome
Fairbanks
Anchorage
Attu
Kodiak
Juneau
ALASKA
Madison
Iowa City
Lansing
Springfield
Indianapolis
Jefferson City
Painesville
Harrisburg
Columbus
Cincinnati
Charleston
Frankfort
Richmond
Buffalo
Albany
Barre
New York City
Washington, D.C.
Nashville
Gastonia
Little Rock
Columbia
Atlanta
Montgomery
Jackson
New Orleans
Jacksonville
Miami
Ancon
PANAMA CANAL ZONE
GUAM
Agana
P.R. & V.I.
San Juan

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, May 1971

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Precipitation				
						Number of samples	Total depth (mm)	Field estimation of deposition		
			Maximum	Minimum	Average[a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	11	4	1	2	2	45	2	45	7
Alaska:	Anchorage	0				0				
	Attu Island	31	0	0	0	0				
	Fairbanks	0				0				
	Juneau	1	3	3	3	1	33	1	33	0
	Kodiak	7	0	0	0	0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	6	5	2	3	0				
Ark:	Little Rock	9	3	1	1	0				
Calif:	Berkeley	18	1	0	0	0				
	Los Angeles	10	4	1	1	0				
C.Z:	Ancon	16	0	0	0	0				
Colo:	Denver	8	5	1	3	2	4	[b]		
Conn:	Hartford	20	2	0	1	7	87	7	87	2
Del:	Dover	9	1	0	1	0				
D.C:	Washington	16	1	0	1	0				
Fla:	Jacksonville	8	2	1	1	3	45	[b]		
	Miami	9	1	0	0	1	20	1	20	0
Ga:	Atlanta	20	1	1	1	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	9	1	0	1	1	19	[b]		
Idaho:	Boise	9	3	1	2	0				
Ill:	Springfield	0				0				
Ind:	Indianapolis	9	2	0	1	0				
Iowa:	Iowa City	10	3	1	2	3	21	3	21	0
Kans:	Topeka	8	3	1	2	5	55	5	55	11
Ky:	Frankfort	0				0				
La:	New Orleans	10	1	1	1	2	13	[b]		
Maine:	Augusta	20	1	0	0	7	107	7	107	0
Md:	Baltimore	9	2	1	1	2	18	2	18	11
Mass:	Lawrence	20	2	0	1	6	82	6	82	3
	Winchester	20	3	0	1	6	90	6	90	0
Mich:	Lansing	7	2	0	1	3	22	3	22	3
Minn:	Minneapolis	7	2	0	1	4	114	4	114	33
Miss:	Jackson	7	1	0	1	1	48	1	48	0
Mo:	Jefferson City	9	3	1	2	2	50	2	50	6
Mont:	Helena	12	4	1	2	4	18	4	18	0
Nebr:	Lincoln	8	6	1	3	3	59	3	59	22
Nev:	Las Vegas	8	3	2	2	0				
N.H:	Concord	0				0				
N.J:	Trenton	20	2	0	1	9	87	9	87	13
N. Mex:	Santa Fe	10	3	1	2	0				
N.Y:	Albany	17	1	0	0	5	59	5	59	29
	Buffalo	9	3	0	1	0				
	New York City	0				0				
N.C:	Gastonia	8	10	2	5	0				
N. Dak:	Bismarck	9	4	1	2	2	12	2	12	3
Ohio:	Cincinnati	0				0				
	Columbus	2	2	1	1	0				
	Painesville	8	3	1	2	3	52	3	52	0
Okla:	Oklahoma City	4	3	1	1	0				
	Ponca City	10	5	0	2	2	49	2	49	0
Oreg:	Portland	9	1	0	1	4	10	4	10	1
Pa:	Harrisburg	8	2	1	1	0				
P.R:	San Juan	2	1	1	1	0				
R.I:	Providence	19	2	0	1	0				
S.C:	Columbia	8	3	1	1	1	13	1	13	0
S. Dak:	Pierre	6	5	2	3	0				
Tenn:	Nashville	7	2	1	1	4	42	4	42	7
Tex:	Austin	0				0				
	El Paso	0				0				
Utah:	Salt Lake City	15	9	1	2	4	10	4	10	1
Vt:	Barre	20	3	0	1	10	80	10	80	15
Va:	Richmond	10	1	0	1	2	59	2	59	1
Wash:	Seattle	3	0	0	0	2	10	[b]		
	Spokane	4	2	1	1	0				
W. Va:	Charleston	9	3	1	1	4	17	4	17	2
Wisc:	Madison	11	2	0	1	2	18	2	18	2
Wyo:	Cheyenne	10	5	2	3	2	20	2	20	2
Network summary		619	10	0	1	121	50	4	47	6

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

2. Canadian Air and Precipitation Monitoring Program,[1] May 1971

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for May 1971 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, May 1971

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	17	0.7	0.2	0.4	47	2.22
Coral Harbour	5	.4	.1	.3	506	3.23
Edmonton	23	.6	.5	.6	570	9.83
Ft. Churchill	5	.2	.1	.2	(a)	2.93
Fredericton	3	.3	.2	.2	204	19.72
Goose Bay	5	.2	.1	.1	99	7.75
Halifax	35	.3	.2	.3	116	23.70
Inuvik	5	.1	.0	.1	209	.72
Montreal	5	.5	.2	.4	311	12.16
Moosonee	5	.5	.3	.4	47	1.90
Ottawa	5	.5	.2	.4	218	9.71
Quebec	5	.5	.2	.4	183	18.21
Regina	5	.6	.4	.5	863	5.91
Resolute	5	.3	.1	.2	16	.25
St. John's, Nfld	5	.2	.1	.1	186	7.86
Saskatoon	5	.4	.3	.4	NS	NS
Sault Ste. Marie	5	.6	.3	.4	224	18.53
Thunder Bay	5	.3	.2	.3	206	35.88
Toronto	5	.4	.1	.3	NS	NS
Vancouver	29	.5	.2	.3	297	12.58
Whitehorse	5	.3	.2	.2	(a)	2.66
Windsor	5	.5	.3	.4	41	1.54
Winnipeg	5	.4	.2	.3	233	10.93
Yellowknife	4	.3	.1	.2	157	3.14
Network summary	201	0.7	0.0	0.3	237	9.66

[a] Less than 0.1 inch rainfall.
NS, no sample.

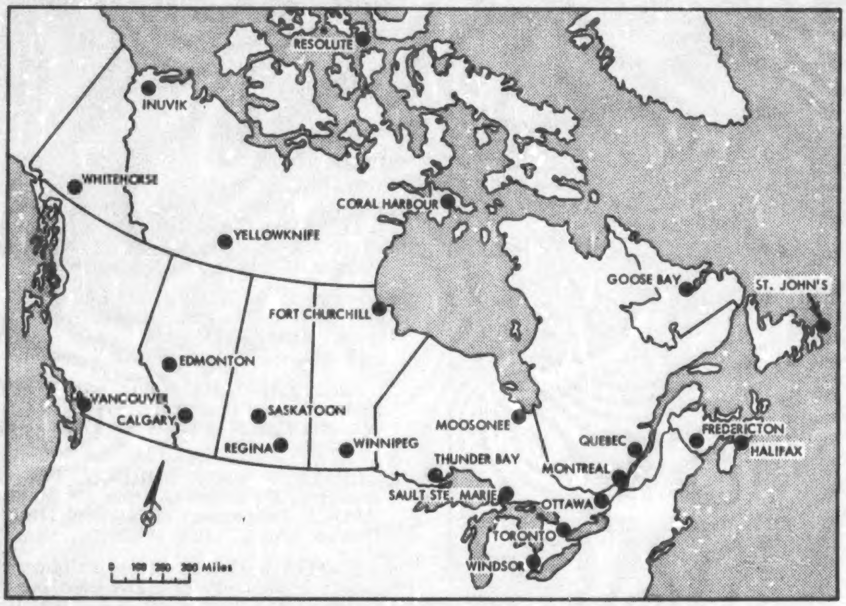
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
FREDERICTON
QUEBEC
HALIFAX
REGINA
WINNIPEG
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
0 100 200 300 Miles

Figure 2. Canadian air and precipitation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

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3. Pan American Air Sampling Program May 1971

Pan American Health Organization and *Environmental Protection Agency*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiation monitoring programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The May 1971 air monitoring results from the participating countries are given in table 3.

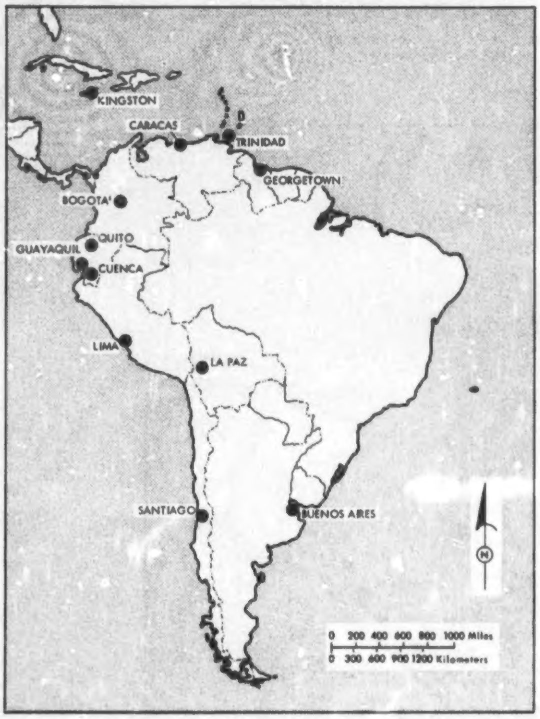

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, May 1971

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	8	0.04	0.02	0.03
Chile:	Santiago	30	.16	.02	.10
Colombia:	Bogota	14	.05	.00	.01
Ecuador:	Cuenca	0			
	Guayaquil	14	.07	.03	.05
	Quito	0			
Guyana:	Georgetown	3	.36	.31	.33
Jamaica:	Kingston	0			
Peru:	Lima	25	1.34	.01	.09
Venezuela:	Caracas	5	.62	.10	.35
West Indies:	Trinidad	19	.79	.01	.42
Pan American summary		118	1.34	0.00	0.14

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Strontium-90 in Human Bone, October-December 1970[1]

Office of Radiation Programs
Environmental Protection Agency

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older age groups have shown their bone strontium-90 content to be low and age independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Bureau of Radiological Health at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium-90 is measured by tributyl phosphate extraction of its yttrium

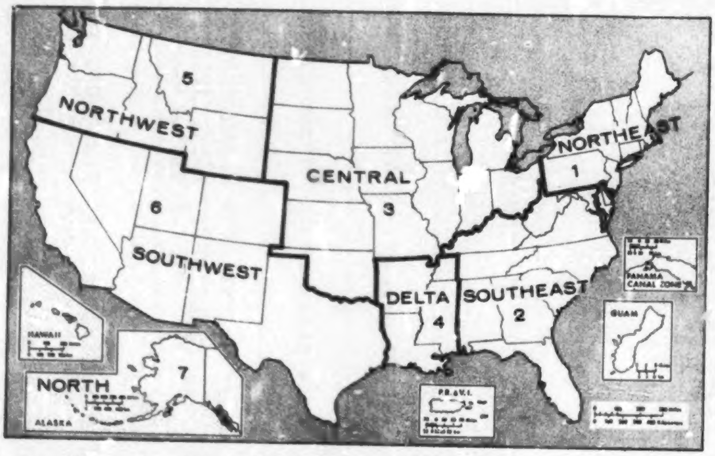

Figure 1. Geographical regions for human bone sampling

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[1] Period during which death or surgical procedure occurred.

Table 1. Strontium-90 in human bone, October–December 1970

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Northeast:						
Massachusetts	V	2	F	63.9±10.9	36.1	1.77
	V	2	F	63.7± 9.5	27.1	2.35
New York	V	2	F	103.5±13.8	40.2	2.57
	V	3	F	127.5±11.9	31.3	4.07
Massachusetts	V	4	F	44.9± 7.8	23.9	1.88
	V	5	F	49.9± 8.5	22.4	2.22
New Hampshire	V	5	M	45.5± 7.0	28.3	1.61
New York	V	5	F	49.1± 7.0	16.4	2.99
Massachusetts	V	6	M	62.5± 8.8	40.3	1.55
New York	V	7	M	46.9± 6.8	24.9	1.88
	V	7	M	86.0± 8.6	50.8	1.69
	V	8	M	28.1± 4.3	15.2	1.85
	V	10	M	60.8± 7.3	32.2	1.89
	V	11	M	47.7± 6.7	30.7	1.55
	V	12	F	65.3± 9.8	37.8	1.73
New Jersey	V,R,S,LB	13	F	108.3±13.0	67.4	1.61
Massachusetts	V	13	F	68.0± 8.7	46.2	1.47
	V	14	F	143.2±12.1	56.4	2.54
New York	V	14	M	65.1± 7.8	37.0	1.76
Connecticut	V	17	M	75.1± 9.3	45.9	1.64
Massachusetts	V	17	F	141.6±17.6	51.7	2.74
Pennsylvania	V	17	F	90.2± 8.9	48.0	1.88
New York	V	17	M	97.7± 9.0	52.6	1.86
New Jersey	V	19	F	86.6± 7.7	48.0	1.80
New York	V	19	M	77.3± 8.1	50.1	1.54
Pennsylvania	V	19	M	45.0± [illegible]	30.7	1.46
New York	V	19	M	102.2± 8.8	50.0	2.04
Connecticut	V,R	20	M	166.7±12.0	60.7	2.75
New Jersey	V,R,S,LB	21	M	107.4± 8.1	48.5	2.22
New York	V	22	M	56.7± 7.3	36.2	1.57
	V	22	M	65.0± 7.3	57.6	1.13
	V	24	F	104.9±10.7	54.1	1.94
	V	25	M	94.5±10.3	42.4	2.23
Southeast:						
South Carolina	V	0	M	154.4±13.3	28.5	5.42
	V	1	F	62.8±12.4	27.4	2.29
	V	2	F	111.7± 9.3	25.9	4.31
North Carolina	V	3	F	228.6±16.3	27.8	8.24
	V	3	F	123.3±12.2	28.5	4.33
South Carolina	V	5	F	98.1±11.7	44.7	2.20
	V	7	M	63.8± 6.9	20.9	3.05
Maryland	V	11	F	111.0±10.7	40.1	2.77
	V	11	M	54.3± 7.0	32.0	1.70
South Carolina	V	14	F	98.1± 8.9	42.3	2.32
Maryland	V	14	F	73.7± 9.4	40.9	1.80
South Carolina	V	14	M	117.5±12.1	47.9	2.45
	V	15	M	91.7± 9.0	43.4	2.11
Maryland	V	15	M	64.1± 8.7	36.0	1.78
	V	16	M	109.4±12.8	57.0	1.92
	V	16	F	96.5±10.8	46.7	2.07
	V	18	M	99.8±11.7	57.8	1.73
South Carolina	V	18	M	132.2±10.9	52.9	2.50
Maryland	V	18	M	100.3±10.0	50.1	2.00
South Carolina	V	18	M	80.5±10.1	47.0	1.71
Maryland	V	19	F	89.3±11.2	46.2	1.93
	V	19	M	101.7±14.3	54.1	1.88
	V	19	M	90.2±10.3	56.6	1.59
South Carolina	V	19	M	79.7± 7.7	47.5	1.68
	V	20	M	106.5±10.9	51.1	2.08
	V	21	M	127.4±10.4	51.1	2.49
	V	21	F	109.9±10.8	61.2	1.80
	V	21	F	90.5± 9.9	40.2	2.25
Maryland	V	22	M	61.3± 7.9	36.5	1.68
	V	22	M	121.9±12.2	57.0	2.14
	V	22	F	91.0± 9.2	35.6	2.56
	V	23	M	125.2±11.9	52.6	2.38
South Carolina	V	23	M	87.1± 8.8	67.6	1.29
Maryland	V	24	M	61.8± 8.5	58.0	1.06
	V	24	F	68.2±11.1	48.3	1.41
	V	25	F	69.0±10.8	46.6	1.48
South Carolina	V	25	F	123.1±12.0	66.2	1.86
Central:						
Ohio	V	0	M	66.0±10.6	47.2	1.40
Iowa	V	2	M	56.5± 6.3	27.7	2.04
Ohio	V	2	F	102.5±11.9	32.2	3.18
Michigan	V	2	F	117.0±12.3	36.5	3.20
Ohio	V	2	M	48.1± 8.6	33.6	1.43
Minnesota	V	3	M	88.8±11.4	38.7	2.30
Wisconsin	V	5	M	26.4± 4.9	21.7	1.21
	V	6	M	83.8± 7.5	34.4	2.44
Ohio	V	7	M	73.3±11.9	79.4	0.92
Wisconsin	V	8	M	41.3± 6.5	27.4	1.51
Ohio	V	14	M	76.5±10.4	38.0	2.01
Wisconsin	V	14	F	72.2± 8.3	52.6	1.37
Ohio	V	14	M	70.7± 7.4	33.8	2.09
Iowa	V	15	M	101.1± 8.6	54.6	1.85
Ohio	V	16	M	119.3±13.9	43.9	2.72
	V	16	M	77.8± 9.4	62.0	1.25

See footnotes at end of table.

Table 1. Strontium-90 in human bone, October–December 1970—continued

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Central:						
Ohio	V	16	M	73.9±10.9	50.8	1.46
Michigan	V	17	M	127.0±10.4	62.3	2.04
Ohio	V	17	M	95.5± 9.8	46.2	2.07
	V	17	F	125.8±10.1	55.7	2.26
	V	18	M	83.8± 8.6	54.7	1.53
	V	18	M	96.0± 9.6	50.1	1.92
	V	20	M	77.4±10.2	58.6	1.32
	V	20	M	116.0±10.2	47.8	2.43
Michigan	V	20	M	69.5±10.4	49.5	1.41
Ohio	V	20	M	67.7± 8.3	50.5	1.34
	V	21	M	86.3±12.2	57.8	1.49
	V	21	F	91.2±11.9	49.8	1.83
	V	22	M	108.2±10.4	52.1	2.08
	V	22	M	57.2± 7.3	42.1	1.36
Indiana	V	22	F	57.7± 7.3	57.0	1.01
Ohio	V	23	M	57.2± 7.8	40.3	1.42
Indiana	V	23	M	68.3±10.4	56.9	1.20
Ohio	V	24	M	105.1±12.0	63.8	1.65
	V	24	M	92.7± 9.2	57.1	1.62
	V	24	M	69.7±11.0	66.9	1.04
	V	25	M	72.9± 8.5	51.6	1.41
Delta:						
Louisiana	V	2	M	59.5±10.0	35.0	1.70
	V	3	M	112.4±10.3	27.0	4.16
	V	20	M	81.9±11.3	47.5	1.72
	V	21	F	74.7± 8.9	42.6	1.75
Northwest:						
Oregon	V	4	F	44.1± 6.7	36.8	1.20
Washington	V	17	M	50.6± 7.8	45.1	1.12
Oregon	V	17	F	137.7± 9.8	41.1	3.35
Washington	V	19	M	374.8±19.3	46.1	8.12
Oregon	V	19	M	85.8± 8.2	53.2	1.61
Southwest:						
Texas	V	5	M	31.1± 5.1	25.4	1.22
	V	11	F	96.3±10.1	41.1	2.34
	V	20	F	54.4± 6.8	49.9	1.09
California	V	22	M	72.5± 9.3	65.7	1.10

[a] Type of bone, V, vertebrae; R, rib; S, sternum; LB, long bones.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.

daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated (*3*) from the yttrium-90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples.

The analytical results for strontium-90 in individual bones from persons dying during the fourth quarter (October-December) of 1970 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium-90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–6*).

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April–June 1970	April 1971
July–September 1970	June 1971

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Feed Materials Production Center and Portsmouth Area Gaseous Diffusion Plant.

1. Feed Materials Production Center[2] July–December 1970

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the Atomic Energy Commission (AEC). The location as related to populated areas is shown in figure 1. Cincinnati and Hamilton, the larger nearby communities, are situated 20 and 10 miles from the center, respectively. Operations at this center are concerned with the processing of high-grade uranium concentrates into metallic uranium. These processes include acid digestion of the concentrates, organic phase extraction of uranyl nitrate, subsequent conversion of the uranyl nitrate to uranium oxide and tetrafluoride, reduction to uranium metal, and fabrication of the metal into fuel elements.

The FMPC also processes thorium to produce purified thorium compounds and metal. The production methods are similar to those used in producing uranium.

During the many involved reactions and processes that lead to the production of reactor fuels, liquid and airborne wastes are generated which contain varying quantities of uranium and thorium. Several in-plant methods are used to curtail their release into the environment surrounding the plant. Almost complete removal of the materials is accomplished by using dust collectors and waste treatment processses. An environmental monitoring program has been established

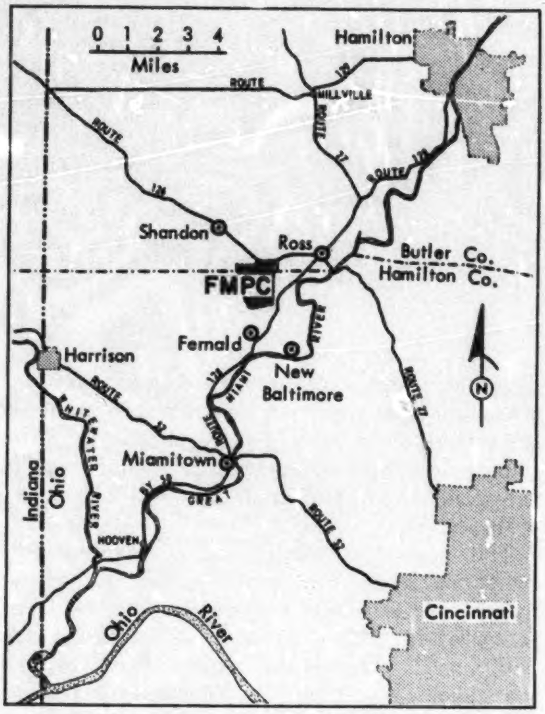

Figure 1. Area map of Feed Materials Production Center

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

[2] Summarized from "Feed Materials Production Center Environmental Monitoring Semiannual Report for the Second Half of 1970" (NLCO-1079).

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to determine the concentrations of plant materials in the water and air outside the project.

Air monitoring

Onsite air samples are obtained from four permanent perimeter air sampling stations, located at the four corners of the production area as shown in figure 2. Samples from these perimeter stations are collected once each week and analyzed for uranium and gross alpha and gross beta radioactivity. Offsite samples are collected by a mobile air sampling unit. The location at which samples are collected is determined by local meteorological conditions on the day of sampling. Approximately 80 percent of all samples are taken downwind of the FMPC plant. Replicate samples are taken at each sampling point and averaged to obtain a representative concentration for that location. An analysis for thorium is not considered necessary because of the small amount of thorium handled in the center. Concentrations of uranium and alpha and beta radioactivity of airborne particulates sampled at onsite and offsite locations are given in table 1.

The results of sampling indicate that the concentrations at onsite locations averaged 1.6 percent, 2.1 percent, and 0.01 percent of the AEC standards for uranium, alpha radioactivity, and beta radioactivity, respectively, and the offsite concentrations averaged 1.77 percent, 1.77 percent, and 0.02 percent of the AEC standards for uranium, alpha radioactivity, and beta radioactivity.

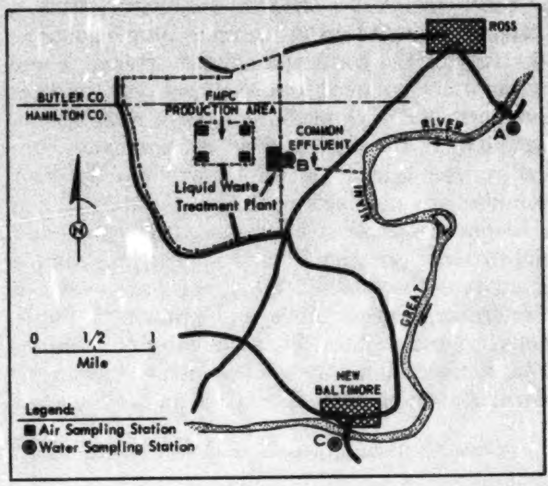

Figure 2. Air and water sampling stations, FMPC

Water monitoring

Each of the individual production plants on the center has collection sumps and treatment equipment to remove the uranium from the process wastewater. The effluents from the plants are collected at a general sump for additional treatment and settling. The clear water from the sump is pumped to the river. The solid portion is pumped to a chemical waste pit for further settling. The clear effluent from the pit is then

Table 1. Radioactivity levels of airborne particulates, Feed Materials Production Center, July–December 1970

Location	Number of samples	Uranium concentration[a] (pCi/m^3)			Alpha radioactivity[a] (pCi/m^3)			Beta radioactivity[b] (pCi/m^3)		
		Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Onsite:										
Southwest	25	0.08	0.01	0.03	0.10	0.01	0.04	0.31	0.01	0.13
Northwest	25	.08	.01	.03	.16	.01	.04	.21	.04	.10
Northeast	25	.13	.01	.04	.18	.01	.05	.24	.02	.11
Southeast	25	.10	.01	.03	.16	.01	.04	.24	.01	.11
All onsite samples	100			0.03			0.04			0.11
Offsite:										
0–2 miles from FMPC	20	.11	.01	.05	.13	.01	.05	1.51	.05	.26
2–4 miles from FMPC	18	.08	.01	.03	.07	.01	.03	.21	.05	.13
4–8 miles from FMPC	28	.12	.01	.03	.12	.01	.03	.54	.01	.22
8–12 miles from FMPC	8	.04	.01	.03	.04	.01	.03	.15	.07	.10
All offsite samples	74			0.04			0.04			0.20

[a] AEC radiation protection standard—2 pCi/m^3 (natural uranium).
[b] AEC radiation protection standard—1 nCi/m^3 (thorium-234).

combined with three other types of project wastewater and discharged via a common effluent outfall into the Great Miami River. At location B, a water sampler is used in conjunction with a Parshal Flume to collect samples proportional to the flow of the combined effluent stream. These samples are removed and analyzed daily and results are used with measurements of river flow in calculating the radioactive contaminant concentrations added to the river. Weekly spot samples are obtained upstream (location A); a continuous sample is taken for a 24-hour period downstream (location C) and at least one sample is analyzed each week. All samples are analyzed for uranium, gross alpha and gross beta radioactivity, and radium-228, a daughter of thorium-232. Since radium-228 has the lowest AEC standard, control of this radionuclide and of the gross radioactivity insures that the AEC standards for the thorium decay chain are not exceeded.

The average concentrations of all sampled contaminants at the downstream position indicate that each contaminant was well below the AEC standard. It may be concluded from sampling and calculations that the FMPC effluent produced little change in the river's quality. The results of the FMPC water monitoring program for July–December 1970 are summarized in table 2.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1969	August 1970
January–June 1970	March 1971

Table 2. Radioactivity in the Great Miami River, Feed Materials Production Center, July–December 1970

Location	Number of samples	Uranium[a] (pCi/liter)			Alpha radioactivity[b] (pCi/liter)			Beta radioactivity[b] (pCi/liter)			Number of samples	Radium-228[c] (pCi/liter)		
		Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average		Maximum	Minimum	Average
Sewer outfall[d] (location B)	183	7	<1	1	9	<1	1	24	<1	18	7	0.2	<0.1	0.1
Upstream from outfall (location A)	25	81	<1	7	105	<1	18	100	<1	23	6	.5	.5	.5
Downstream from outfall (location C)	27	16	<1	3	27	<1	7	27	<1	14	6	2.3	.5	1.0

[a] AEC standard—20 nCi/liter (natural uranium).
[b] AEC standard—3 nCi/liter (certain mixtures of alpha and beta emitters).
[c] AEC standard—30 pCi/liter (radium-228).
[d] Concentrations in the river as calculated from sewer outfall samples results.

2. Portsmouth Area Gaseous Diffusion Plant[3]
July–December 1970

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium-234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. To verify the effectiveness of plant controls, environmental monitoring is conducted for evidence of alpha-particle, beta-particle, and gamma-ray emitters.

Air samples are taken at four offsite locations at a frequency of three 1,000 cubic-foot samples per week. In selecting sample locations, the prevailing wind direction and the locations with the highest radioactivity concentrations were considered.

Water samples are collected monthly at each location as shown in table 3. The one-half gallon sample is analyzed for gross alpha and gross beta-gamma radioactivity. Moderate volumes of low-level water wastes are discharged to the Scioto River system by way of Little Beaver Creek, Big Beaver Creek and Salt Creek. Sampling point distribution is as follows: one on each of the three plant drainage ditches; one on Salt Creek; three each on the Little Beaver Creek, the Big Beaver Creek, and the Scioto River.

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[3] Data summarized from B. Kalmon and S. H. Hulett, "Environmental Radiation Levels and Concentrations, Second Half and Annual Summaries 1970," (April 20, 1970).

Table 3. Radioactivity in water, Portsmouth Plant, July–December 1970

Location	Number of samples	Alpha radioactivity concentration (pCi/m^3)			Average as a percent of AEC standards[a]	Beta-gamma radioactivity concentration (pCi/m^3)			Average as a percent of AEC standards[a]
		High	Low	Average		High	Low	Average	
1	6	31.5	1.8	7.6	0.03	7.0	7.0	7.0	0.04
2	6	26.0	.3	7.4	.02	18.0	7.0	8.6	.04
3[b]	5	216	.9	44.7	.15	194	7.0	36.8	.18
4	6	3.6	.3	1.9	.01	58.5	7.0	18.8	.09
5	6	185	.3	32.0	.11	49.5	7.0	22.1	.11
6	6	40.5	.5	11.7	.04	31.5	7.0	12.7	.06
7	6	148	50	78.8	.26	1,660	104	458	2.28
8	6	238	54	126	.42	1,400	166	560	2.80
10[b]	6	320	2.7	99	.33	61	7.0	25.9	.13
11[b]	6	356	99	194	.63	2,840	90	843	4.22
12	6	99	.5	19.9	.07	45	7.0	20.6	.10
13	6	63	2.3	28.9	.10	423	18.0	134	.07
14	6	9.0	.3	3.7	.01	27	7.0	10.1	.05
Summary	77	356	0.3	50.4	.17	2,840	7.0	166	0.83

[a] The AEC radiation protection standard for alpha radioactivity in water—30 nCi/liter; beta-gamma radioactivity—20 nCi/liter; sensitivity of analysis, alpha radioactivity—0.5 pCi/liter; beta radioactivity—14.0 pCi/liter.

[b] Composite sample.

Table 4. Radioactivity in air, Portsmouth Plant, July–December 1970

Location	Number of samples	Alpha radioactivity concentration (fCi/m^3)			Average as a percent of AEC standards[a]	Beta-gamma radioactivity concentration (pCi/m^3)			Average as a percent of AEC standards[a]
		High	Low	Average		High	Low	Average	
3	74	274	<16	48	1.21	1.4	<0.016	0.35	0.04
12	74	403	<16	32	.81	1.8	< .016	.35	.04
24	72	596	<16	48	1.21	1.9	< .016	.39	.04
29	72	386	<16	48	1.21	1.4	< .016	.31	.03
Summary	292	596	<16	44	1.10	1.9	<0.016	0.35	0.04

[a] The AEC radiation protection standard for alpha radioactivity in air—4 pCi/m^3; beta-gamma radioactivity—1 nCi/m^3; sensitivity of analysis for both alpha and beta radioactivity is 16.1 fCi/m^3.

The frequency of composite sampling of water is determined by the flow at each of the three plant drainage ditches. The composite sample is collected in a 55-gallon drum. After thoroughly mixing the water in the drum, a one-half gallon sample is drawn off each month and the drum drained. The average concentrations in the Scioto River have been substantially below the AEC radiation protection standards for population groups in uncontrolled areas without need for control of releases.

For July–December 1970, the alpha and beta-gamma radioactivity in water, and the alpha radioactivity in air increased when compared with the first half of 1970.

Penetrating background dose rates for the second half of 1970 increased when compared with the first half of 1970. External gamma radiation levels are taken at each of four locations three times per week. Measurements are taken with a calibrated Geiger-Mueller tube at a height of 1 foot above ground level. These measurements are extrapolated to a distance of 3 feet. The 3-foot value has been experimentally determined as being approximately two-thirds that at the 1-foot level. These results are tabulated in mrem/h. Starting in January 1971, the background radiation level will be taken at 3 feet above ground.

Average alpha and beta-gamma radioactivity

Table 5 Background exposure rates, Portsmouth Plant, July–December 1970

Location	Background rate[a] (μrem/h)			Background average rate extrapolated to 3-foot level (μrem/h)
	High	Low	Average	
3	16.7	10.9	13.8	9.1
12	21.9	10.2	12.8	8.4
24	18.8	10.2	14.5	9.6
29	17.6	10.5	14.2	9.4
Summary	21.9	10.2	13.8	9.1

[a] Open-shield Geiger tube 1 foot above ground; limit of sensitivity—0.1 μrem/h.

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concentrations in air are summarized in table 4. Table 3 contains the average alpha and beta-gamma radioactivity concentrations in water. The external gamma-ray levels, measured at the sampling locations shown in figure 3, are summarized in table 5. The overall average concentrations and background exposure rates for January–December 1969 and January–June 1970, July–December 1970, and January–December 1970 are presented in table 6.

Table 6. Comparison of average concentrations Portsmouth, January 1969–December 1970

Type of monitoring	Percent of AEC standard[a]			
	January–December 1969	January–June 1970	July–December 1970	January–December 1970
Air				
Alpha radioactivity	5.70	0.91	1.10	1.05
Beta-gamma radioactivity	.03	.07	.04	.05
Water				
Alpha radioactivity	.20	.06	.17	.12
Beta-gamma radioactivity	.32	.22	.83	.54
Background exposure extrapolated to 3 feet above ground level (μrem/h)	8.2	8.1	9.1	9.0

[a] See footnote (a) of table 3.

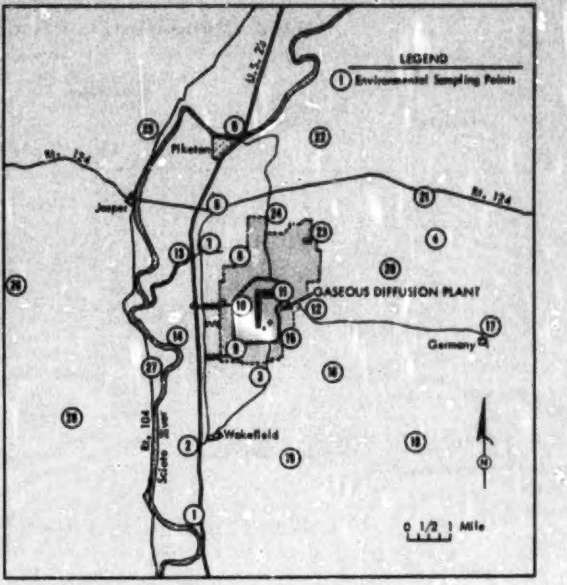
LEGEND
① Environmental Sampling Points
U.S. 23
Rt. 124
Piketon
Jasper
GASEOUS DIFFUSION PLANT
Germany
Wakefield
Rt. 104
Scioto River
0 1/2 1 Mile
N

Figure 3. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

Recent coverage in Radiological *Health Data and Reports:*

Period	Issue
July–December 1969	October 1970
January–June 1970	April 1971

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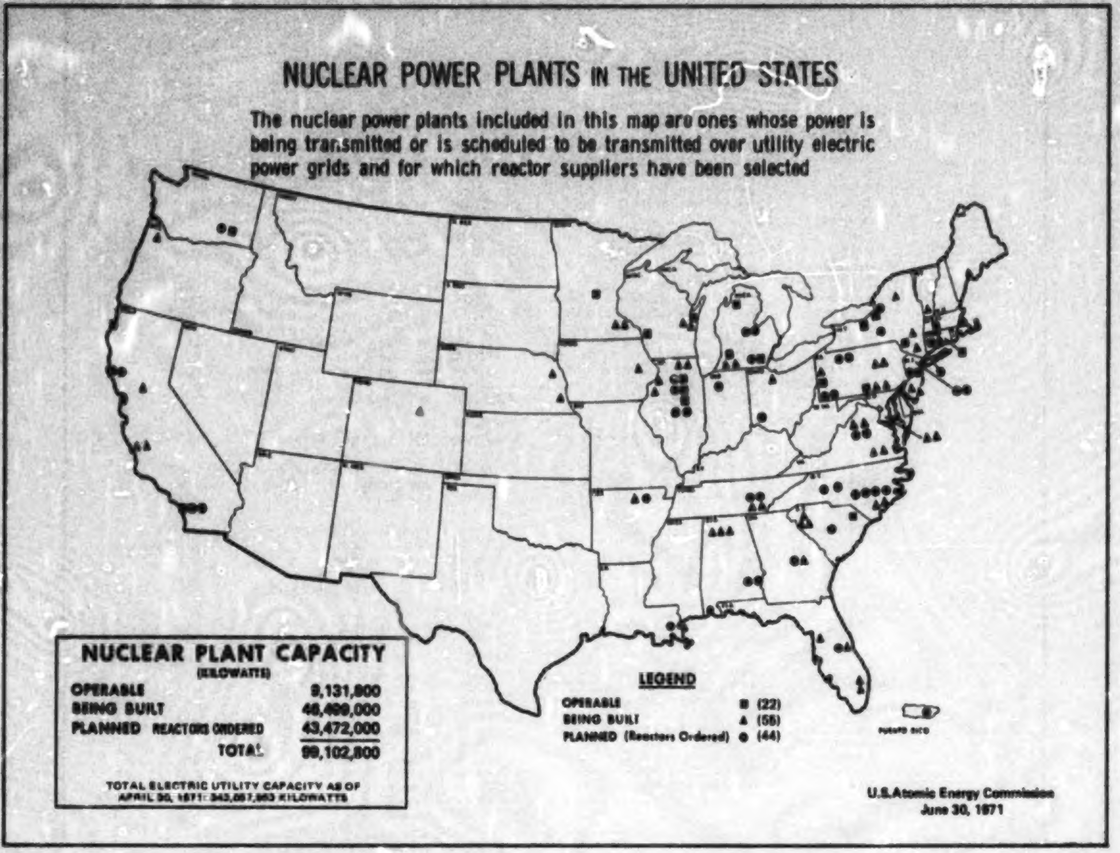
NUCLEAR POWER PLANTS IN THE UNITED STATES
The nuclear power plants included in this map are ones whose power is being transmitted or is scheduled to be transmitted over utility electric power grids and for which reactor suppliers have been selected
NUCLEAR PLANT CAPACITY
(KILOWATTS)
OPERABLE 9,131,800
BEING BUILT 46,499,000
PLANNED REACTORS ORDERED 43,472,000
TOTAL 99,102,800
TOTAL ELECTRIC UTILITY CAPACITY AS OF APRIL 30, 1971: 343,057,953 KILOWATTS
LEGEND
OPERABLE ■ (22)
BEING BUILT ▲ (55)
PLANNED (Reactors Ordered) ● (44)
PUERTO RICO

U.S.Atomic Energy Commission
June 30, 1971

Figure 1. Nuclear power plants in the United States

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SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,065,000	Tennessee Valley Authority	1972
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,065,000	Tennessee Valley Authority	1972
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,065,000	Tennessee Valley Authority	1973
Dothan	Joseph M. Farley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
ARKANSAS				
London	Arkansas Nuclear One: Unit 1	820,000	Arkansas Power & Light Co.	1973
London	Arkansas Nuclear One: Unit 2	920,000	Arkansas Power & Light Co.	1975
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant: Unit 3	68,500	Pacific Gas & Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1967
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1975
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1976
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,060,000	Pacific Gas & Electric Co.	1974
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,080,000	Pacific Gas & Electric Co.	1975
Clay Station	Rancho Seco Nuclear Generation Station	804,000	Sacramento Municipal Utility District	1973
Mendocino County	Mendocino Power Plant: Unit 1	1,128,000	Pacific Gas & Electric Co.	1976
Mendocino County	Mendocino Power Plant: Unit 2	1,128,000	Pacific Gas & Electric Co.	1978
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1972
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1967
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1970
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
FLORIDA				
Turkey Point	Turkey Point Station: Unit 3	693,000	Florida Power & Light Co.	1971
Turkey Point	Turkey Point Station: Unit 4	693,000	Florida Power & Light Co.	1972
Red Level	Crystal River Plant: Unit 3	858,000	Florida Power Corp.	1972
Ft. Pierce	Hutchinson Island: Unit 1	800,000	Florida Power and Light Co.	1974
Ft. Pierce	Hutchinson Island: Unit 2	800,000	Florida Power and Light Co.	1976
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1973
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	786,000	Georgia Power Co.	1976
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	809,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	809,000	Commonwealth Edison Co.	1971
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1972
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1973
Cordova	Quad-Cities Station: Unit 1	809,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1971
Cordova	Quad-Cities Station: Unit 2	809,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Seneca	LaSalle Co. Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co.-Ia.	1975
Seneca	LaSalle Co. Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.-Ia.	1976
•	–	1,100,000	Comm. Edison Co.	1978
•	–	1,100,000	Comm. Edison Co.	1979
INDIANA				
Dune Acres	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1976
IOWA				
Cedar Rapids	Duane Arnold Energy Center: Unit 1	529,700	Iowa Electric Light and Power Co.	1973
LOUISIANA				
Taft	Waterford Generating Station: Unit 1	1,165,000	Louisiana Power & Light Co.	1976
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1973
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1974
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station	655,000	Boston Edison Co.	1971
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1963
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1971
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 1	60,900	Detroit Edison Co.	1970
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,123,000	Detroit Edison Co.	1973
Bridgman	Donald C. Cook Plant: Unit 1	1,054,000	Indiana & Michigan Electric Co.	1973
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1974
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1976
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1977
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1971
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1972
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1972
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1973

Figure 1. Nuclear power plants in the United States—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	560,000	Jersey Central Power & Light Co.	1969
Lacey Township	Forked River Generating Station: Unit 1	1,140,000	Jersey Central Power & Light Co.	1975
Salem	Salem Nuclear Generating Station: Unit 1	1,050,000	Public Service Electric and Gas, N. J.	1973
Salem	Salem Nuclear Generating Station: Unit 2	1,050,000	Public Service Electric and Gas, N. J.	1974
Bordentown	Newbold Nuclear Generating Station: Unit 1	1,088,000	Public Service Electric and Gas, N. J.	1976
Bordentown	Newbold Nuclear Generating Station: Unit 2	1,088,000	Public Service Electric and Gas, N. J.	1977
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1963
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1971
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1973
Scriba	Nine Mile Point Nuclear Station	625,000	Niagara Mohawk Power Co.	1970
Rochester	R. E. Ginna Nuclear Power Plant: Unit 1	420,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1975
Lansing	Bell Station	838,000	New York State Electric & Gas Co.	1978
Verplanck	Verplanck: Unit 1	1,115,000	Consolidated Edison Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N. Y.	1973
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,150,000	Duke Power Co.	1975
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,150,000	Duke Power Co.	1977
Bonsal	Shearon Harris Plant: Unit 1	900,000	Carolina Power & Light Co.	1977
Bonsal	Shearon Harris Plant: Unit 2	900,000	Carolina Power & Light Co.	1978
Bonsal	Shearon Harris Plant: Unit 3	900,000	Carolina Power & Light Co.	1979
Bonsal	Shearon Harris Plant: Unit 4	900,000	Carolina Power & Light Co.	1980
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station	872,000	Toledo Edison-Cleveland Electric Illuminating Co.	1974
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1974
OREGON				
Prescott	Trojan Station	1,130,000	Portland General Electric Co.	1974
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1973
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1974
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1975
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1977
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	847,000	Duquesne Light Co.-Ohio Edison Co.	1973
Middletown	Three Mile Island Nuclear Station: Unit 1	831,000	Metropolitan Edison Co.	1972
Middletown	Three Mile Island Nuclear Station: Unit 2	907,000	Jersey Central Power & Light Co.	1974
Berwick	Susquehanna Steam Electric Station: Unit 1	1,052,000	Pennsylvania Power and Light	1977
Berwick	Susquehanna Steam Electric Station: Unit 2	1,052,000	Pennsylvania Power and Light	1980
SOUTH CAROLINA				
Hartsville	H. B. Robinson S. E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconee Nuclear Station: Unit 1	841,000	Duke Power Co.	1971
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1972
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1973
Parr	Virgil C.Summer Nuclear Station: Unit 1	900,000	South Carolina Electric & Gas Co.	1977
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,124,000	Tennessee Valley Authority	1974
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,124,000	Tennessee Valley Authority	1974
Spring City	Watts Bar Nuclear Plant: Unit 1	1,169,000	Tennessee Valley Authority	1976
Spring City	Watts Bar Nuclear Plant: Unit 2	1,169,000	Tennessee Valley Authority	1977
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.	1971
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	788,000	Virginia Electric & Power Co.	1972
Gravel Neck	Surry Power Station: Unit 2	788,000	Virginia Electric & Power Co.	1972
Mineral	North Anna Power Station: Unit 1	845,000	Virginia Electric & Power Co.	1974
Mineral	North Anna Power Station: Unit 2	845,000	Virginia Electric & Power Co.	1975
Mineral	North Anna Power Station: Unit 3	900,000	Virginia Electric & Power Co.	1977
Mineral	North Anna Power Station: Unit 4	900,000	Virginia Electric & Power Co.	1978
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	790,000	Atomic Energy Commission	1968
Richland	Hanford No. 2	1,103,000	Washington Public Power Supply System	1977
WISCONSIN				
Genoa	Genoa Nuclear Generating Station	50,000	Dairyland Power Cooperative	1969
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1971
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1971
Carlton	Kewaunee Nuclear Power Plant: Unit 1	540,000	Wisconsin Public Service Co.	1972
PUERTO RICO				
Puerto De Jobos	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1975
*	–	1,201,000	Tennessee Valley Authority	1977
*	–	1,201,000	Tennessee Valley Authority	1978

* Site not selected.

Figure 1. Nuclear power plants in the United States—continued

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Reported Nuclear Detonations, August 1971

(Includes seismic signals presumably from foreign nuclear detonations)

The U. S. Atomic Energy Commission announced only one nuclear detonation for August 1971. This underground nuclear test was in the low-intermediate yield range (20–200 kilotons TNT equivalent) and was conducted August 18, 1971, at its Nevada Test Site.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

PREOPERATIONAL RADIOLOGICAL SURVEILLANCE OF THE FLORIDA POWER CORPORATION'S CRYSTAL RIVER POWER REACTOR SITE.

C. L. Nayfield, W. Johnson, and *B. P. Prewitt. Radiological Health Data and Reports, Vol. 9,* August 1971, pp. 441–449.

Preoperational radiological surveillance has been conducted by the Florida Division of Health around the Crystal River nuclear power generating plant site of the Florida Power Corporation since May 1969. A summary of these data with reference to statistically significant differences between sampling locations is presented, and comparisons are made with other locations in the State for which data are available.

KEYWORDS: Florida, nuclear power plant, surveillance, radiological.

EVALUATION OF THE SAMPLING FREQUENCY OF THE PASTEURIZED MILK NETWORK.

J. L. Stein, R. E. Jaquish, and *T. J. Sharpe. Radiological Health Data and Reports,* Vol. 8, August 1971, pp. 451–455.

The Pasteurized Milk Network (PMN) of the Environmental Protection Agency reduced its milk sampling frequency from weekly to monthly in July 1970. A review of the effect of this reduced sampling frequency from a statistical viewpoint, on the capability of the network to carry out the surveillance requirements outlined by guides of the Federal Radiation Council is presented. The study determined that, based on the presently accepted radiation protection guides, the reduced frequency of milk collection does not sacrifice the precision requirement for a public health evaluation of current levels of radionuclides in the nation's pasteurized milk supply.

KEYWORDS: Pasteurized Milk Network, milk surveillance, sampling frequency, precision, statistics.

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